APPENDIX A: SEA ICE NOMENCLATURE, ARRANGED BY SUBJECT

[Courtesy of the World Meteorological Organization (WMO 1970)]

1. FLOATING ICE: Any form of ice found floating in water. The principal kinds of floating ice are *lake ice, river ice,* and *sea ice* which form by the freezing of water at the surface, and *glacier ice (ice of land origin)* formed on land or in an ice shelf. The concept includes ice that is stranded or grounded.

1.1 **Sea ice:** Any form of ice found at sea which has originated from the freezing of seawater.

1.2 **Ice of land origin:** Ice formed on land or in an ice shelf found floating in water. The concept includes ice that is stranded or grounded.

1.3 **Lake ice:** Ice formed on a lake, regardless of observed location.

1.4 **River ice:** Ice formed on a river, regardless of observed location.

2. DEVELOPMENT

2.1 **New ice:** A general term for recently formed ice, which includes *frazil ice, grease ice, slush* and *shuga.* These types of ice are composed of ice crystals which are only weakly frozen together (if at all) and have a definite form only while they are afloat.

2.1.1 FRAZIL ICE: Fine spicules or plates of ice, suspended in water.

2.1.2 GREASE ICE: A later stage of freezing than *frazil ice* when the crystals have coagulated to form a soupy layer on the surface. Grease ice reflects little light, giving the sea a matt appearance.

2.1.3 SLUSH: Snow which is saturated and mixed with water on land or ice surfaces, or as a viscous floating mass in water after a heavy snowfall.

2.1.4 SHUGA: An accumulation of spongy white ice lumps, a few centimetres across; they are formed from *grease ice* or *slush* and sometimes from *anchor ice* rising to the surface.

2.2 **Nilas:** A thin elastic crust of ice, easily bending on waves and swell and under pressure, thrusting in a pattern of interlocking "fingers" *(finger rafting).* Has a matt surface and is up to 10 cm in thickness. May be subdivided into *dark nilas* and *light nilas.*

2.2.1 DARK NILAS: *Nilas* which is under 5 cm in thickness and is very dark in colour.

2.2.2 LIGHT NILAS: *Nilas* which is more than 5 cm in thickness and rather lighter in colour than *dark nilas.*

2.2.3 ICE RIND: A brittle shiny crust of ice formed on a quiet surface by direct freezing or from *grease ice,* usually in water of low salinity. Thickness to about 5 cm. Easily broken by wind or swell, commonly breaking in rectangular pieces.

2.3 **Pancake ice:** cf. 4.3.1.

2.4 **Young ice:** Ice in the transition stage between *nilas* and *first-year ice,* 10–30 cm in thickness. May be subdivided into *grey ice* and *grey-white ice.*

2.4.1 GREY ICE: *Young ice* 10–15 cm thick. Less elastic than *nilas* and breaks on swell. Usually rafts under pressure.

2.4.2 GREY-WHITE ICE: *Young ice* 15–30 cm thick. Under pressure more likely to ridge than to raft.

2.5 **First-year ice:** *Sea ice* of not more than one winter's growth, developing from *young ice;* thickness 30 cm–2 m. May be subdivided into *thin first-year ice / white ice, medium first-year ice* and *thick first-year ice.*

2.5.1 THIN FIRST-YEAR ICE/WHITE ICE: *First-year ice* 30–70 cm thick.

2.5.2 MEDIUM FIRST-YEAR ICE: *First-year ice* 70–120 cm thick.

2.5.3 THICK FIRST-YEAR ICE: *First-year ice* over 120 cm thick.

2.6 **Old ice:** *Sea ice* that has survived at least one summer's melt. Most topographic features are smoother than on *first-year ice*. May be subdivided into *second-year ice* and *multi-year ice.*

2.6.1 SECOND-YEAR ICE: *Old ice* which has survived only one summer's melt. Because it is thicker and less dense than *first-year ice,* it stands higher out of the water. In contrast to *multi-year ice,* summer melting produces a regular pattern of numerous small puddles. Bare patches and puddles are usually greenish-blue.

2.6.2 MULTI-YEAR ICE: *Old ice* up to 3 m thick or more which has survived at least two summers' melt. *Hummocks* even smoother than in *second-year ice,* and the ice is almost salt-free. Colour, where bare, is usually blue. Melt pattern consists of large interconnecting irregular puddles and a well-developed drainage system.

3. FORMS OF FAST ICE

3.1 **Fast ice:** *Sea ice* which forms and remains fast along the coast, where it is attached to the shore, to an *ice wall,* to an *ice front,* between shoals or grounded *icebergs*. Vertical fluctuations may be observed during changes of sea-level. Fast ice may be formed *in situ* from sea water or by freezing of *pack ice* of any age to the shore, and it may extend a few metres or several hundred kilometres from the coast. Fast ice may be more than one year old and may then be prefixed with the appropriate age category (*old, second-year,* or *multi-year*). If it is thicker than about 2 m above sea level it is called an *ice shelf.*

3.1.1 YOUNG COASTAL ICE: The initial stage of *fast ice* formation consisting of *nilas* or *young ice*, its width varying from a few metres up to l00–200 m from the shoreline.

3.2 **Icefoot:** A narrow fringe of ice attached to the coast, unmoved by tides and remaining after the *fast ice* has moved away.

3.3 **Anchor ice:** Submerged ice attached or anchored to the bottom, irrespective of the nature of its formation.

3.4 **Grounded ice:** *Floating ice* that is aground in shoal water (cf. *stranded ice*).

3.4.1 STRANDED ICE: Ice which has been floating and has been deposited on the shore by retreating high water.

3.4.2 GROUNDED HUMMOCK: Hummocked *grounded ice* formation. There are single grounded *hummocks* and lines (or chains) of *hummocks*.

STAMUKHA*: A hummock or ridge of *grounded ice*, typically on an isolated shoal, formed by heaping up of ice blocks.

4. PACK ICE: Term used in a wide sense to include any area of *sea ice,* other than *fast ice*, no matter what form it takes or how it is disposed.

4.1 **Ice cover:** The ratio of an area of ice of any concentration to the total area of sea surface within some large geographic locale; this locale may be global, hemispheric, or prescribed by a specific oceanographic entity such as Baffin Bay or the Barents Sea.

4.2 **Concentration:** The ratio expressed in tenths or oktas describing the mean areal density of ice in a given area.

4.2.1 COMPACT PACK ICE: *Pack ice* in which the *concentration* is 10/10 (8/8) and no water is visible.

4.2.1.1 *Consolidated pack ice: Pack ice* in which the *concentration* is 10/10 (8/8) and the floes are frozen together.

4.2.2 VERY CLOSE PACK ICE: Pack ice in which the concentration is 9/10 to less than 10/10 (7/8 to less than 8/8).

4.2.3 CLOSE PACK ICE: Pack ice in which the concentration is 7/10 to 8/10 (6/8 to less than 7/8), composed of floes mostly in contact.

4.2.4 OPEN PACK ICE: Pack ice in which the ice concentration is 4/10 to 6/10 (3/8 to less than 6/8), with many leads and polynyas, and the floes are generally not in contact with one another.

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*This term does not appear in the WMO from Sea Ice Nomenclature. The definition was instead taken from *The Glossary of Geology* (1980). Bates, R.L. and J.A. Jackson (Ed.), American Geological Institute, Falls Church, VA, p. 607.

4.2.5 Very open pack ice: *Pack ice* in which the *concentration* is 1/10 to 3/10 (1/8 to less than 3/8) and water preponderates over ice.

4.2.6 Open water: A large area of freely navigable water in which *sea ice* is present in *concentrations* less than 1/10 (1/8). There may be *ice of land origin* present, although the total *concentration* of all ice shall not exceed 1/10 (1/8).

4.2.7 Bergy water: An area of freely navigable water with no *sea ice* present but in which *ice of land origin* is present.

4.2.8 Ice-free: No ice present. If ice of any kind is present, this term should not be used.

4.3 **Forms of floating ice**

4.3.1 Pancake ice: Predominantly circular pieces of ice from 30 cm – 3 m in diameter, and up to about 10 cm in thickness, with raised rims due to the pieces striking against one another. It may be formed on a slight swell from *grease ice*, *shuga* or *slush* or as a result of the breaking of *ice rind, nilas* or, under severe conditions of swell or waves, of *grey ice*. It also sometimes forms at some depth, at an interface between water bodies of different physical characteristics, from where it floats to the surface; its appearance may rapidly cover wide areas of water.

4.3.2 Floe: Any relatively flat piece of *sea ice* 20 m or more across. Floes are subdivided according to horizontal extent as follows:

4.3.2.1 *Giant*: Over 10 km across.

4.3.2.2 *Vast:* 2–10 km across.

4.3.2.3 *Big:* 500–2,000 m across.

4.3.2.4 *Medium*: l00–500 m across.

4.3.2.5 *Small*: 20–100 m across.

4.3.3 Ice cake: Any relatively flat piece of *sea ice* less than 20 m across.

4.3.3.1 *Small ice cake*: An *ice cake* that is less than 2 m across.

4.3.4 Floeberg: A massive piece of *sea ice* composed of a *hummock*, or a group of *hummocks*, frozen together and separated from any ice surroundings. It may float up to 5 m above sea-level.

4.3.5 Ice breccia: Ice pieces of different age frozen together.

4.3.6 Brash ice: Accumulations of *floating ice* made up of fragments not more than 2 m across, the wreckage of other forms of ice.

4.3.7 Iceberg: cf. 10.4.2.

4.3.8 Glacier berg: cf. 10.4.2.1.

4.3.9 Tabular berg: cf. 10.4.2.2.

4.3.10 Ice island: cf. 10.4.3.

4.3.11 Bergy bit: cf. 10.4.4.

4.3.12 Growler: cf. 10.4.5.

4.4 **Arrangement**

4.4.1 Ice field: Area of *pack ice* consisting of any size of *floes*, which is greater than 10 km across (cf. patch).

4.4.1.1 *Large ice field*: An *ice field* over 20 km across.

4.4.1.2 *Medium ice field:* An *ice field* 15–20 km across.

4.4.1.3 *Small ice field*: An *ice field* l0–15 km across.

4.4.1.4 *Ice patch*: An area of *pack ice* less than 10 km across.

4.4.2 Ice massif: A concentration of *sea ice* covering hundreds of square kilometres, which is found in the same region every summer.

4.4.3 Belt: A large feature of *pack ice* arrangement, longer than it is wide, from 1 km to more than 100 km in width.

4.4.4 Tongue: A projection of the ice edge up to several kilometres in length, caused by wind or current.

4.4.5 Strip: Long narrow area of *pack ice*, about 1 km or less in width, usually composed of small fragments detached from the main mass of ice, and run together under the influence of wind, swell or current.

4.4.6 BIGHT: An extensive crescent-shaped indentation in the *ice edge*, formed by either wind or current.

4.4.7 ICE JAM: An accumulation of broken *river ice* or *sea ice* caught in a narrow channel.

4.4.8 ICE EDGE: The demarcation at any given time between the open sea and *sea ice* of any kind, whether fast or drifting. It may be termed compacted or *diffuse* (cf. *ice boundary*).

4.4.8.1 *Compacted ice edge*: Close, clear-cut *ice edge* compacted by wind or current; usually on the windward side of an area of *pack ice*.

4.4.8.2 *Diffuse ice edge*: Poorly defined *ice edge* limiting an area of dispersed ice; usually on the leeward side of an area of *pack ice*.

4.4.8.3 *Ice limit*: Climatological term referring to the extreme minimum or extreme maximum extent of the *ice edge* in any given month or period based on observations over a number of years. Term should be preceded by minimum or maximum (cf. *mean ice edge*).

4.4.8.4 *Mean ice edge*: Average position of the *ice edge* in any given month or period based on observations over a number of years. Other terms which may be used are mean maximum ice edge and mean minimum ice edge (cf. *ice limit*).

4.4.8.5 *Fast-ice edge*: The demarcation at any given time between *fast ice* and *open water.*

4.4.9 ICE BOUNDARY: The demarcation at any given time between *fast ice* and *pack ice* or between areas of *pack ice* of different *concentrations* (cf. ice edge).

4.4.9.1 *Fast-ice boundary*: The *ice boundary* at any given time between *fast ice* and *pack ice*.

4.4.9.2 *Concentration boundary*: A line approximating the transition between two areas of *pack ice* with distinctly different *concentrations*.

4.4.10 *Iceberg tongue*: cf. 10.4.2.3.

5. PACK-ICE MOTION PROCESSES

5.1 **Diverging:** *Ice fields* or *floes* in an area are subjected to diverging or dispersive motion, thus reducing ice *concentration* and/or relieving stresses in the ice.

5.2 **Compacting:** Pieces of *floating ice* are said to be compacting when they are subjected to a converging motion, which increases ice *concentration* and/or produces stresses which may result in ice deformation.

5.3 **Shearing:** An area of *pack ice* is subject to shear when the ice motion varies significantly in the direction normal to the motion, subjecting the ice to rotational forces. These forces may result in phenomena similar to a *flaw* (q.v.).

6. DEFORMATION PROCESSES

6.1 **Fracturing:** Pressure process whereby ice is permanently deformed, and rupture occurs. Most commonly used to describe breaking across *very close pack ice, compact pack ice* and *consolidated pack ice*.

6.2 **Hummocking:** The pressure process by which *sea ice* is forced into *hummocks.* When the floes rotate in the process it is termed screwing.

6.3 **Ridging:** The pressure process by which *sea ice* is forced into *ridges.*

6.4 **Rafting:** Pressure processes whereby one piece of ice overrides another. Most common in *new* and *young ice* (cf. *finger rafting*).

6.4.1 FINGER RAFTING: Type of rafting whereby interlocking thrusts are formed, each floe thrusting "fingers" alternately over and under the other. Common in *nilas* and *grey ice*.

6.5 **Weathering:** Processes of ablation and accumulation which gradually eliminate irregularities in an ice surface.

7. OPENINGS IN THE ICE

7.1 **Fracture:** Any break or rupture through *very close pack ice, compact pack ice, consolidated pack ice, fast ice,* or a single *floe* resulting from deformation processes. Fractures may contain *brash ice* and/or be covered with *nilas* and/or *young ice.* Length may vary from a few metres to many kilometres.

7.1.1 CRACK: Any fracture which has not parted.

7.1.1.1 *Tide crack*: Crack at the line of junction between an immovable *ice foot* or *ice wall* and *fast ice*, the latter subject to rise and fall of the tide.

7.1.1.2 *Flaw:* A narrow separation zone between *pack ice* and *fast ice*, where the pieces of ice are in chaotic state; it forms when *pack ice* shears under the effect of a strong wind or current along the *fast ice boundary* (cf. *shearing*).

7.1.2 VERY SMALL FRACTURE: 0 to 50 m wide.

7.1.3 SMALL FRACTURE: 50 to 200 m wide.

7.1.4 MEDIUM FRACTURE: 200 to 500 m wide.

7.1.5 LARGE FRACTURE: More than 500 m wide.

7.2 **Fracture zone:** An area that has a great number of fractures.

7.3 **Lead:** Any *fracture* or passage-way through *sea ice* which is navigable by surface vessels.

7.3.1 SHORE LEAD: A *lead* between *pack ice* and the shore or between *pack ice* and an *ice front.*

7.3.2 FLAW LEAD: A passage-way between *pack ice* and *fast ice* which is navigable by surface vessels.

7.4 **Polynya:** Any non-linear shaped opening enclosed in ice. Polynyas may contain *brash ice* and/or be covered with *new ice, nilas* or *young ice*; submariners refer to these as *skylights*. Sometimes the polynya is limited on one side by the coast and is called a *shore polynya* or by *fast ice* and is called a *flaw polynya*. If it recurs in the same position every year, it is called a *recurring polynya.*

7.4.1 SHORE POLYNYA: A *polynya* between *pack ice* and the coast or between *pack ice* and an *ice front.*

7.4.2 FLAW POLYNYA: A polynya between *pack ice* and *fast ice.*

7.4.3 RECURRING POLYNYA: A *polynya* which recurs in the same position every year.

8. ICE-SURFACE FEATURES

8.1 **Level ice:** *Sea ice* which is unaffected by deformation.

8.2 **Deformed ice:** A general term for ice that has been squeezed together and in places forced upwards (and downwards). Subdivisions are *rafted ice, ridged ice* and *hummocked ice.*

8.2.1 RAFTED ICE: Type of *deformed ice* formed by one piece of ice overriding another (cf. *finger rafting*).

8.2.1.1 *Finger rafted ice*: Type of *rafted ice* in which *floes* thrust "fingers" alternately over and under the other.

8.2.2 RIDGE: A line or wall of broken ice forced up by pressure. May be fresh or weathered. The submerged volume of broken ice under a ridge, forced downwards by pressure, is termed an *ice keel.*

8.2.2.1 *New ridge*: *Ridge* newly formed with sharp peaks and slope of sides usually 40°. Fragments are visible from the air at low altitude.

8.2.2.2 *Weathered ridge*: *Ridge* with peaks slightly rounded and slope of sides usually 30° to 40°. Individual fragments are not discernible.

8.2.2.3 *Very weathered ridge*: *Ridge* with tops very rounded, slope of sides usually 20°–30°.

8.2.2.4 *Aged ridge: Ridge* which has undergone considerable weathering. These ridges are best described as undulations.

8.2.2.5 *Consolidated ridge:* A *ridge* in which the base has frozen together.

8.2.2.6 *Ridged ice:* Ice piled haphazardly one piece over another in the form of ridges or walls.

Usually found in first-year ice (cf. *ridging*).

8.2.2.6.1 *Ridged ice zone:* An area in which much *ridged ice* with similar characteristics has formed.

8.2.3 HUMMOCK: A hillock of broken ice which has been forced upwards by pressure. May be fresh or weathered. The submerged volume of broken ice under the hummock, forced downwards by pressure, is termed a *bummock*.

8.2.3.1 *Hummocked ice: Sea ice* piled haphazardly one piece over another to form an uneven surface. When weathered, has the appearance of smooth hillocks.

8.3 **Standing floe:** A separate *floe* standing vertically or inclined and enclosed by rather smooth ice.

8.4 **Ram:** An underwater ice projection from an *ice wall, ice front, iceberg* or *floe*. Its formation is usually due to a more intensive melting and erosion of the unsubmerged part.

8.5 **Bare ice:** Ice without snow cover.

8.6 **Snow-covered ice:** Ice covered with snow.

8.6.1 SASTRUGI: Sharp, irregular ridges formed on a snow surface by wind erosion and deposition. On mobile *floating ice* the ridges are parallel to the direction of the prevailing wind at the time they were formed.

8.6.2 SNOWDRIFT: An accumulation of wind-blown snow deposited in the lee of obstructions or heaped by wind eddies. A crescent-shaped snowdrift, with ends pointing down-wind, is known as a *snow barchan.*

9. STAGES OF MELTING

9.1 **Puddle:** An accumulation on ice of melt-water, mainly due to melting snow, but in the more advanced stages also to the melting of ice. Initial stage consists of patches of melted snow.

9.2 **Thaw holes:** Vertical holes in *sea ice* formed when surface *puddles* melt through to the underlying water.

9.3 **Dried ice:** *Sea ice* from the surface of which melt-water has disappeared after the formation of *cracks* and *thaw holes.* During the period of drying, the surface whitens.

9.4 **Rotten ice:** *Sea ice* which has become honeycombed and which is in an advanced state of disintegration.

9.5 **Flooded ice:** *Sea ice* which has been flooded by melt-water or river water and is heavily loaded by water and wet snow.

10. ICE OF LAND ORIGIN

10.1 **Firn:** Old snow which has recrystallized into a dense material. Unlike snow, the particles are to some extent joined together; but, unlike ice, the air spaces in it still connect with each other.

10.2 **Glacier ice:** Ice in, or originating from, a *glacier,* whether on land or floating on the sea as *icebergs, bergy bits* or *growlers.*

10.2.1 GLACIER: A mass of snow and ice continuously moving from higher to lower ground or, if afloat, continuously spreading. The principal forms of glacier are: inland ice sheets, *ice shelves, ice streams,* ice caps, ice piedmonts, cirque glaciers and various types of mountain (valley) glaciers.

10.2.2 ICE WALL: An ice cliff forming the seaward margin of a *glacier* that is not afloat. An ice wall is aground, the rock basement being at or below sea-level (cf. *ice front*).

10.2.3 ICE STREAM: Part of an inland ice sheet in which the ice flows more rapidly and not necessarily in the same direction as the surrounding ice. The margins are sometimes clearly marked by a change in direction of the surface slope but may be indistinct.

10.2.4 GLACIER TONGUE: Projecting seaward extension of a *glacier*, usually afloat. In the Antarctic, glacier tongues may extend over many tens of kilometres.

10.3 **Ice shelf:** A floating ice sheet of considerable thickness showing 2–50 m or more above sea-level, attached to the coast. Usually of great horizontal extent and with a level or gently undulating surface. Nourished by annual snow accumulation and often also by the seaward extension of land *glaciers.* Limited areas may be aground. The seaward edge is termed an *ice front* (q.v.).

10.3.1 ICE FRONT: The vertical cliff forming the seaward face of an *ice shelf* or other floating glacier varying in height from 2–50 m or more above sea-level (cf. *ice wall*).

10.4 **Calved ice of land origin**

10.4.1 CALVING: The breaking away of a mass of ice from an ice wall, *ice front* or *iceberg.*

10.4.2 ICEBERG: A massive piece of ice of greatly varying shape, more than 5 m above sea-level, which has broken away from a *glacier,* and which may be afloat or aground. Icebergs may be described as *tabular,* dome-shaped, sloping, pinnacled, weathered or *glacier bergs.*

10.4.2.1 *Glacier berg:* An irregularly shaped *iceberg*.

10.4.2.2 *Tabular berg:* A flat-topped *iceberg*. Most tabular bergs form by *calving* from an *ice shelf* and show horizontal banding (cf. *ice island*).

10.4.2.3 *Iceberg tongue:* A major accumulation of *icebergs* projecting from the coast, held in place by grounding and joined together by *fast ice.*

10.4.3 ICE ISLAND: A large piece of floating ice, about 5 m above sea-level, which has broken away from an Arctic ice shelf, having a thickness of 30–50 m and an area of from a few thousand square metres to 500 sq. km or more, and usually characterized by a regularly undulating surface which gives it a ribbed appearance from the air.

10.4.4 BERGY BIT: A large piece of floating *glacier ice*, generally showing less than 5 m above sea-level but more than 1 m and normally about 100–300 sq. m in area.

10.4.5 GROWLER: Smaller piece of ice than a *bergy bit* or *floeberg*, often transparent but appearing green or almost black in colour, extending less than 1 m above the sea surface and normally occupying an area of about 20 sq. m.

11. SKY AND AIR INDICATIONS

11.1 **Water sky:** Dark streaks on the underside of low clouds, indicating the presence of water features in the vicinity of *sea ice*.

11.2 **Ice blink:** A whitish glare on low clouds above an accumulation of distant ice.

11.3 **Frost smoke:** Fog-like clouds due to contact of cold air with relatively warm water, which can appear over openings in the ice, or leeward of the *ice edge*, and which may persist while ice is forming.

12. TERMS RELATING TO SURFACE SHIPPING

12.1 **Beset:** Situation of a vessel surrounded by ice and unable to move.

12.2 **Ice-bound:** A harbour, inlet, etc. is said to be ice-bound when navigation by ships is prevented on account of ice, except possibly with the assistance of an icebreaker.

12.3 **Nip:** Ice is said to nip when it forcibly presses against a ship. A vessel so caught, though undamaged, is said to have been nipped.

12.4 **Ice under pressure:** Ice in which deformation processes are actively occurring and hence a potential impediment or danger to shipping.

12.5 **Difficult area:** A general qualitative expression to indicate, in a relative manner, that the severity of ice conditions prevailing in an area is such that navigation in it is difficult.

12.6 **Easy area:** A general qualitative expression to indicate, in a relative manner, that ice conditions prevailing in an area are such that navigation in it is not difficult.

12.7 **Iceport:** An embayment in an *ice front,* often of a temporary nature, where ships can moor alongside and unload directly onto the *ice shelf.*

13. TERMS RELATING TO SUBMARINE NAVIGATION

13.1 **Ice canopy:** *Pack ice* from the point of view of the submariner.

13.2 **Friendly ice:** From the point of view of the submariner, an *ice canopy* containing many large *skylights* or other features which permit a submarine to surface. There must be more than ten such features per 30 nautical miles (56 km) along the submarine's track.

13.3 **Hostile ice:** From the point of view of the submariner, an *ice canopy* containing no large *skylights* or other features which permit a submarine to surface.

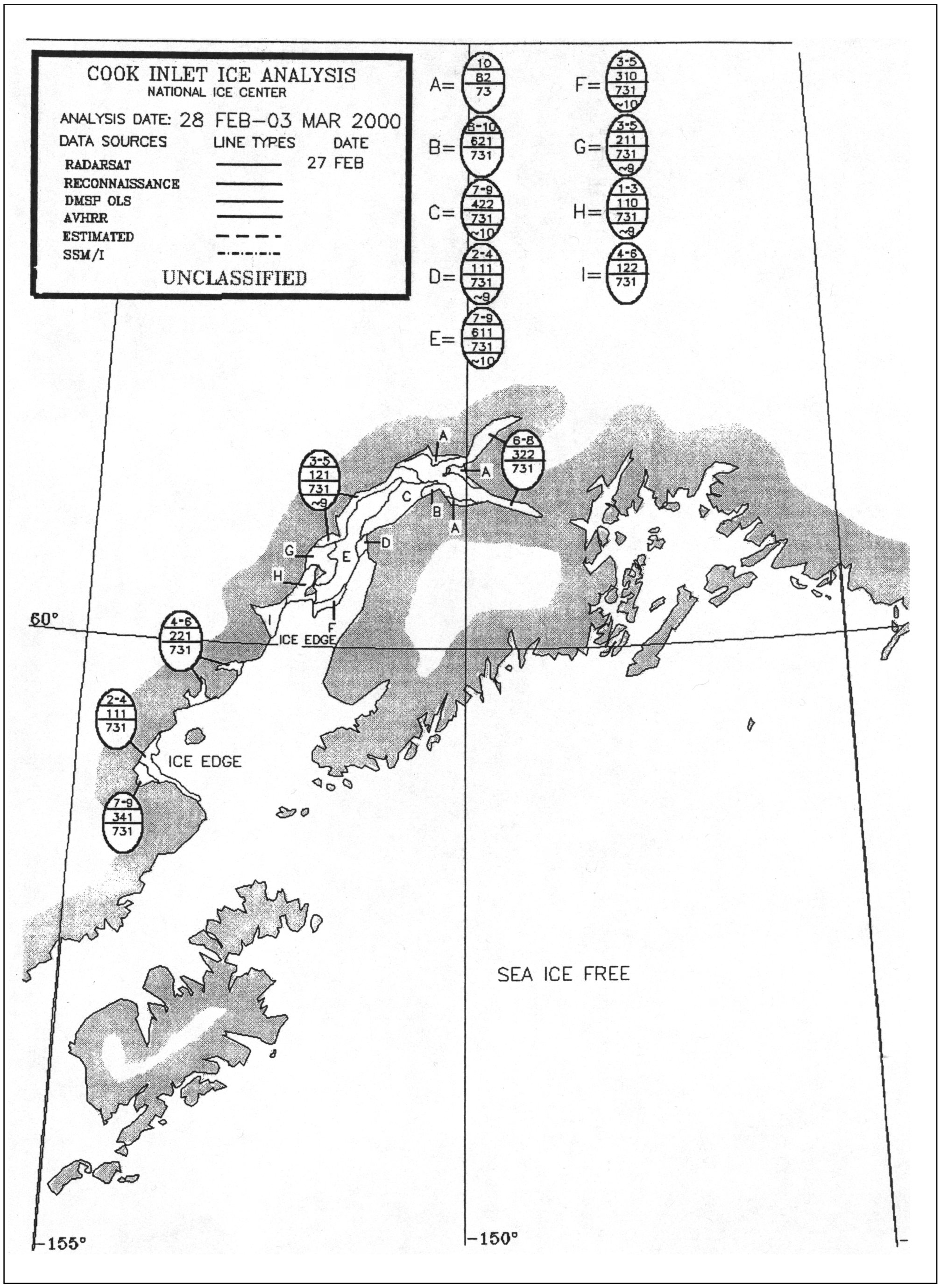
13.4 **Bummock:** From the point of view of the submariner, a downward projection from the under-side of the *ice canopy*; the counterpart of a *hummock.*

13.5 **Ice keel:** From the point of view of the submariner, a downward-projecting ridge on the underside of the *ice canopy*; the counterpart of a ridge. Ice keels may extend as much as 50 m below sea-level.

13.6 **Skylight:** From the point of view of the submariner, thin places in the *ice canopy*, usually less than 1 m thick and appearing from below as relatively light, translucent patches in dark surroundings. The under-surface of a skylight is normally flat. Skylights are called large if big enough for a submarine to attempt to surface through them (120 m), or small if not.

APPENDIX B: EXAMPLE OF A COOK INLET ICE COVER ANALYSIS ISSUED BY THE NATIONAL ICE CENTER (NIC) IN SUITLAND, MARYLAND

The oval symbols on the map refer to the World Meteorological Organization system of sea ice classification, also known as the "Egg Code." The following description of the code comes from a NIC web site*.



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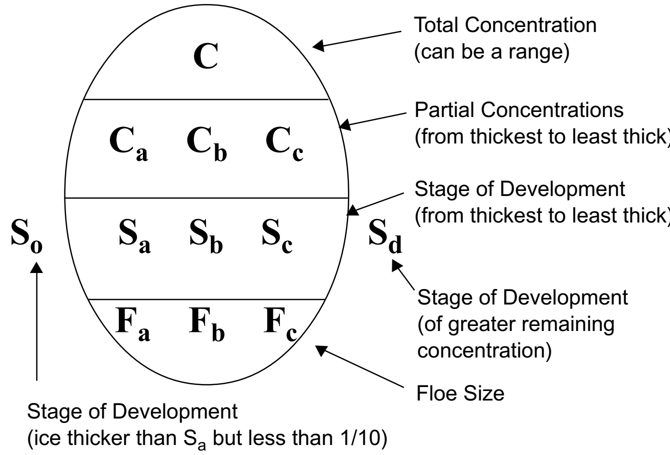
*http://www.natice.noaa.gov/Egg.htm

Total concentration

The total concentration (C) is reported in tenths and is the uppermost group. Concentration may be expressed as a single number or as a range, not to exceed two tenths (i.e., 3-5, 5-7)



Partial concentrations

Partial concentrations (C_a, C_b, C_c) are also reported in tenths, but must be reported as a single digit. These are reported in order of decreasing thickness. That is, C_a is the concentration of the thickness ice and C_c is the concentration of the thinnest ice.

Stages of development

Stages of development (S_a, S_b, S_c, S_o, S_d) are listed using the following code in decreasing order of thickness. These codes are directly correlated with the partial concentrations above. C_a is the concentration of stage S_a, C_b is the concentration of stage S_b, and C_c is the concentration of S_c. S_o is used to report a development with the greatest remaining concentration that will not fit into the egg. If all partial concentrations equal the total concentration and there is an S_d, S_d is considered to be present in a trace amount.

The following codes are used to denote stages of development for sea ice:

Stage of development	*Code figure*
New Ice-Frazil, Grease, Slush, Shuga (0–10 cm)	1
Nilas, Ice Rind (0–10 cm)	2
Young (10–30 cm)	3
Gray (10–15 cm)	4
Gray-White (15–30 cm)	5
First Year (30–120 cm)	6
First Year Thin (30–70 cm)	7
First Year Thin- First Stage (30–70 cm)	8
First Year Thin- Second Stage (30–70 cm)	9
Med First Year (70–120 cm)	1.
Thick First Year (>120 cm)	4.
Old-Survived at least one seasons melt (>2 m)	7.
Second Year (>2 m)	8.
Multi-Year (>2 m)	9.
Ice of Land Origin	▲•

The following codes are used to denote stages of development for freshwater ice:

Stage of development	*Code figure*
New Ice (0–5 cm)	1
Thin Ice (5–15 cm)	4
Medium Ice (15–30 cm)	5
Thick Ice (30–70 cm)	7
First Stage Thick Ice (30–50 cm)	8
Second Stage Thick Ice (50–cm)	9
Very Thick Ice (70–120 cm)	1.

Forms of sea ice

Forms of sea ice (F_a, F_b, F_c) indicate the floe size corresponding to the stages identified in S_a, S_b, and S_c, respectively. The following codes are used to denote forms of sea ice:

Forms of sea ice	*Code figure*
New Ice (0–10 cm)	X
Pancake Ice (30 cm–3 m)	0
Brash Ice (<2 m)	1
Ice Cake (3–20 m)	2
Small Ice Floe (20–100 m)	3
Medium Ice Floe (100–500 m)	4
Big Ice Floe (500 m–2 km)	5
Vast Ice Floe (2–10 km)	6
Giant Ice Floe (>10 km)	7
Fast Ice	8
Ice of Land Origin	9
Undetermined or Unknown (Iceberg, Growlers, Bergy Bits) (Used for F_a, F_b, F_c only)	/

The following codes are used to denote forms of sea ice for freshwater ice:

Forms of sea ice	*Code figure*
Fast Ice	8
Belts and Strips symbol followed by the concentration of ice	~F

APPENDIX C: PROCEDURE USED TO CREATE THE COMPOSITE COOK INLET ICE CHARTS

Three time-series map sets are shown in Section 4. The first set of maps shows the mean ice conditions that have occurred, based on arithmetic averaging of the digitized ice concentration and stage of development data from the available NWS ice charts from December 1984 through March 1999. The second and third sets show the probabliity of occurrence for two specific ice conditions: the occurrence of any marine ice at all, and the occurrence of any ice type having at least 5/10ths concentration.

We developed these maps in the following manner. We transferred the microfiche records to digital images in the tagged information file format (*.tif files) and then used ArcInfo™ GIS software to process each image file. The images were georeferenced to latitude and longitude by manual identification of the geodetic coordinates of several image pixels onscreen. We then used ArcInfo's Registration tool to calculate the rotation and translation parameters required to generate a new image file that was referenced to the geodetic coordinate space. When the root mean square of the transformation least-squares residuals achieved an order of magnitude of –3, the registration was accepted. Using the Rectification tool, we applied the transformation parameters in creating a new georectified image. We then placed a digitized Cook Inlet coastline from a USGS 1:250,000 quad sheet over the image to check for proper image registration. It also guided the technician in making minor spatial corrections from the registered image.

The technician then digitally traced the chart's ice features onscreen, establishing each as a separate and unique polygon, which was linked to a database populated with all of the classification attributes assigned by the NWS forecaster. Two additional data fields were filled with numerical equivalents by the GIS technician—ice concentration and stage—which enabled statistical calculations for these attributes. The database fields and their contents are as follows:

Poly_Label	The letter designation for each polygon that was assigned by the NWS (e.g., A, B, C, etc.).
Rpt_Conc	The ice concentration range reported by the NWS, in tenths (e.g. 7–9).
RptStage_*x*	The various ice stages of development reported by the NWS. Because several types may be assigned to a single polygon, the next seven fields (RptStage_1, … RptStage_7) are available to be filled as needed.
Form	The NWS description of the most advanced ice type for the polygon. It may be shown, for example, as Brash, Strips, Pancake, or Nilas. Because the NWS charts were inconsistent with respect to this classification, we did not use this value in our analyses.
Atlas_Stage	The numerical equivalent assigned by the GIS technician for the most advanced stage of development for the polygon. It is a numeric field with values from 1 to 5, with the more mature ice assigned a higher value. We intended the value to be a conservative estimate of navigation difficulty. The atlas stage codes correspond with the WMO and NWS codes according to the table below.

Stages	*WMO Code*	*WMO Abbrev.*	*NWS Ice Classification*	*Atlas_Stage Code*
New Ice	1	N	N	1
Nilas	2	N	(not reported)	
Young	3	YN	YNG	2
Gray	4	G	(not reported)	
Gray-White	5	GW	(not reported)	
First Year	6	FY	FY	3
First Year Thin	7	FL	FL	4
First Year Thin (First Stage)	8	FL	(not reported)	
First Year Thin (Second Stage)	9	FL	(not reported)	
Medium First Year	1.	FM	FM	5
Thick First Year	4.	FT	(does not occur in Cook Inlet)	
Old	7.		(does not occur in Cook Inlet)	
Second Year	8.	SY	(does not occur in Cook Inlet)	
Multi-Year	9.	MY	(does not occur in Cook Inlet)	
Ice of Land Origin	*.	(not reported)		

Atlas_Conc — The numerical equivalent assigned by the GIS technician for ice concentration. We rounded the mean value to the higher integer if the reported concentration spanned more than two tenths.

Date — The date of the NWS ice analysis chart.

Conf — The confidence level assigned by the NWS, appearing as high, moderate, or low, which was based on the quality of the data used to produce the report. This rating does not appear on every chart, but when it did, it was recorded in this field.

The next phase of our work involved changing the ArcView shape files to a Mercator projection with its central meridian at 155°W and the latitude of true scale at 60°N. We used ArcView's Spatial Analyst extension to convert the themes to ArcInfo grids representing our atlas concentrations and stages. We organized the grid sets into half-month groupings, with the 1st to 15th of each month comprising the first half, and the 16th to the end of the month making up the second half.

In our third phase we performed the statistical calculations and created composite summary maps for each half-month period. Weighting all available grid sets equally for each half-month period, we calculated the mean and standard deviation values of stage and concentration in every grid cell. This was done using ArcInfo's Map Algebra Tools. We reclassified the resulting values into integers according to the following schemes (where V = cell value).

Concentration Reclassification Scheme:

If $V \le 0.5$, then $V = 0$
If $0.5 < V \le 1.5$, then $V = 1$
If $1.5 < V \le 2.5$, then $V = 2$
If $2.5 < V \le 3.5$, then $V = 3$
If $3.5 < V \le 4.5$, then $V = 4$
If $4.5 < V \le 5.5$, then $V = 5$
If $5.5 < V \le 6.5$, then $V = 6$
If $6.5 < V \le 7.5$, then $V = 7$
If $7.5 < V \le 8.5$, then $V = 8$
If $8.5 < V \le 9.5$, then $V = 9$
If $9.5 < V$, then $V = 10$

Stage Reclassification Scheme:

If $V \le 0.25$, then $V = 0$
If $0.25 < V \le 1.5$, then $V = 1$
If $1.5 < V \le 2.5$, then $V = 2$
If $2.5 < V \le 3.5$, then $V = 3$
If $3.5 < V \le 4.5$, then $V = 4$
If $4.5 < V$, then $V = 5$

We used ArcView's Spatial Analyst extension to convert the grid data sets into vector polygon representations and to consolidate contiguous cells with the same value into a single polygon. This step was done separately for both the concentration values and the stage values. Finally, we hand-edited on screen to smooth the polygon shapes and to consolidate orphaned polygon fragments.

Probability distribution ranges were determined for 1) any occurrence of ice and 2) ice of at least 5/10ths concentration (Map Sets 2 and 3, respectively). The calculations were accomplished using the map algebra tools of ArcInfo Grid. Grids for each two-week period were reclassified to create a set of binary grids for any ice and a set for 5/10ths or greater. Cell values were then calculated for the percent occurrence for the selected condition for each respective two-week period from:

$$G_{\mathrm{p}} = \sum_{i=1}^{N} \frac{G_{\mathrm{i}}}{N}$$

where G_{p} = percent probability grid for the two-week period
G_{i} = selected condition individual two-week binary grid
N = total number of grids for the two-week period.

The grid for the two-week period, G_{p}, was reclassified according to the following scheme:

$0 \le V \le 0.01$
$0.01 < V \le 25$
$25 < V \le 50$
$50 < V \le 75$
$75 < V \le 100$.

This produced a grid that depicted probabilities stratified at 25% intervals. This entire procedure is diagrammed in Figure C1.

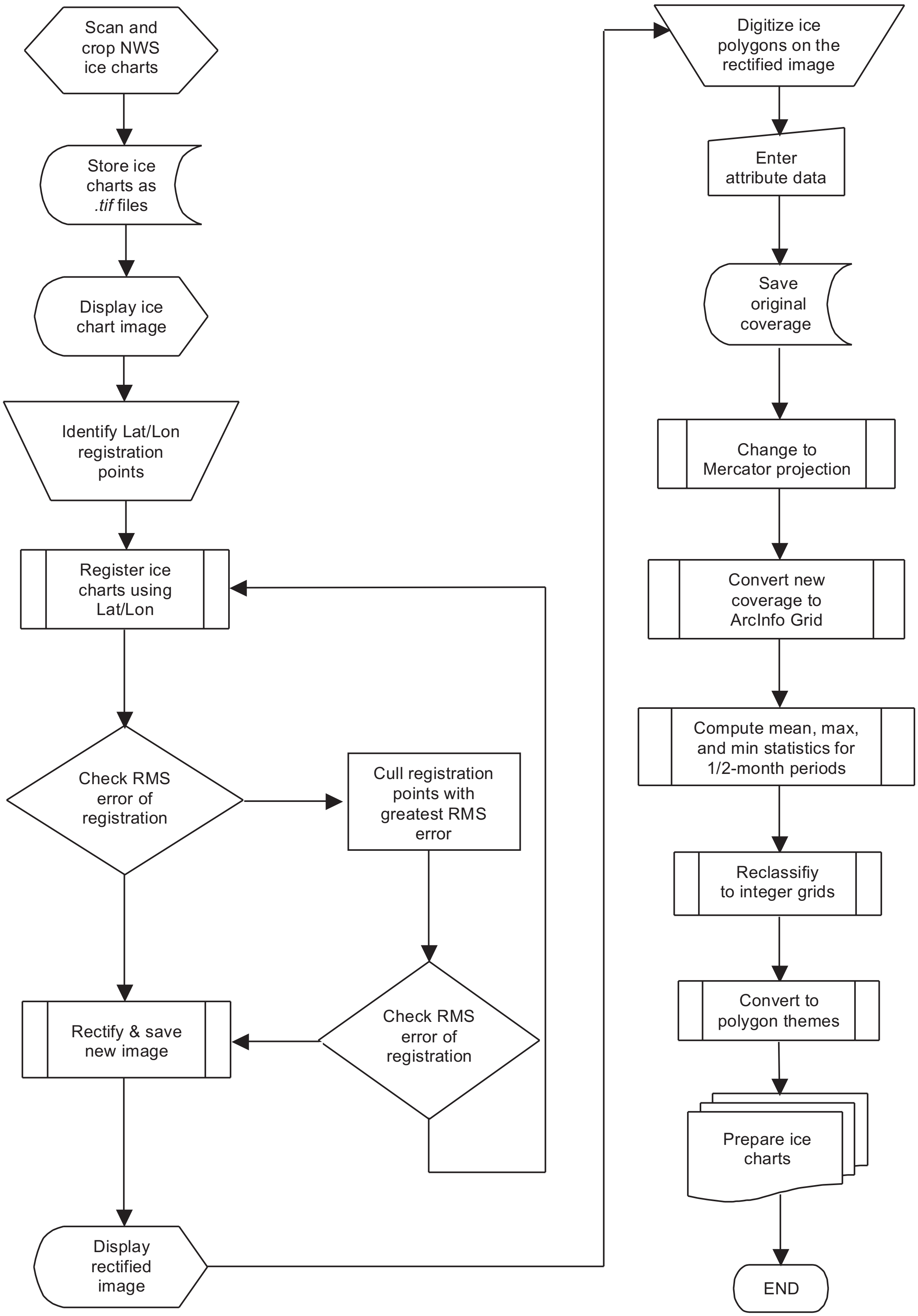
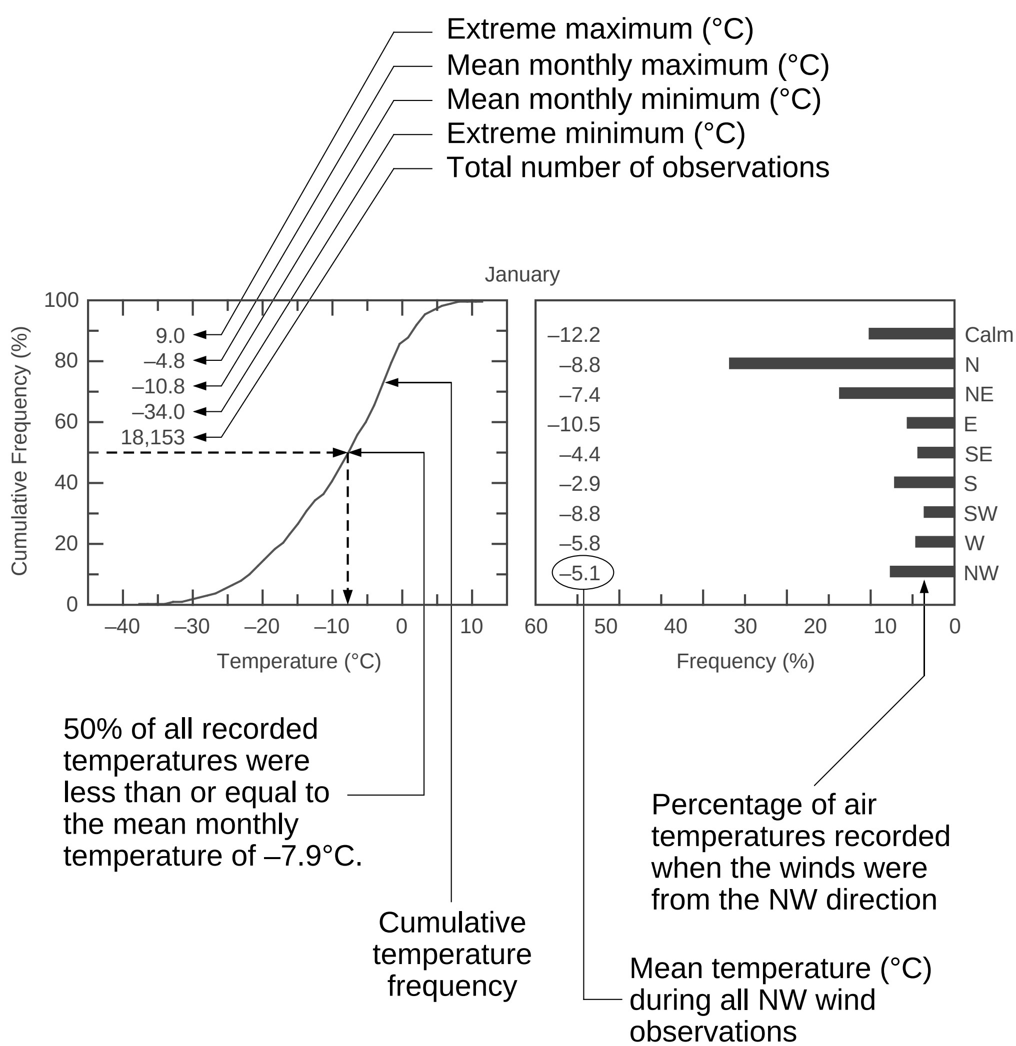
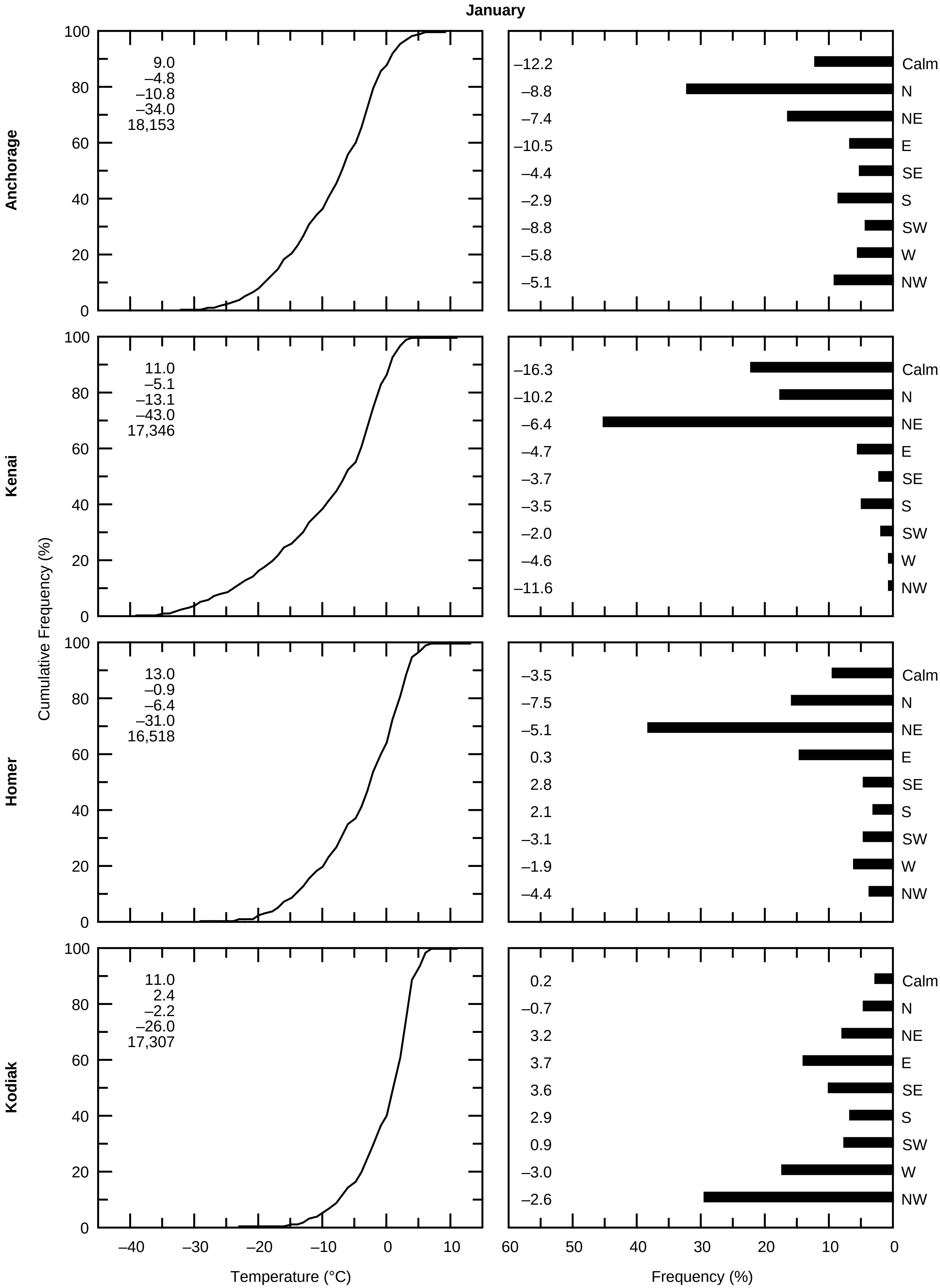


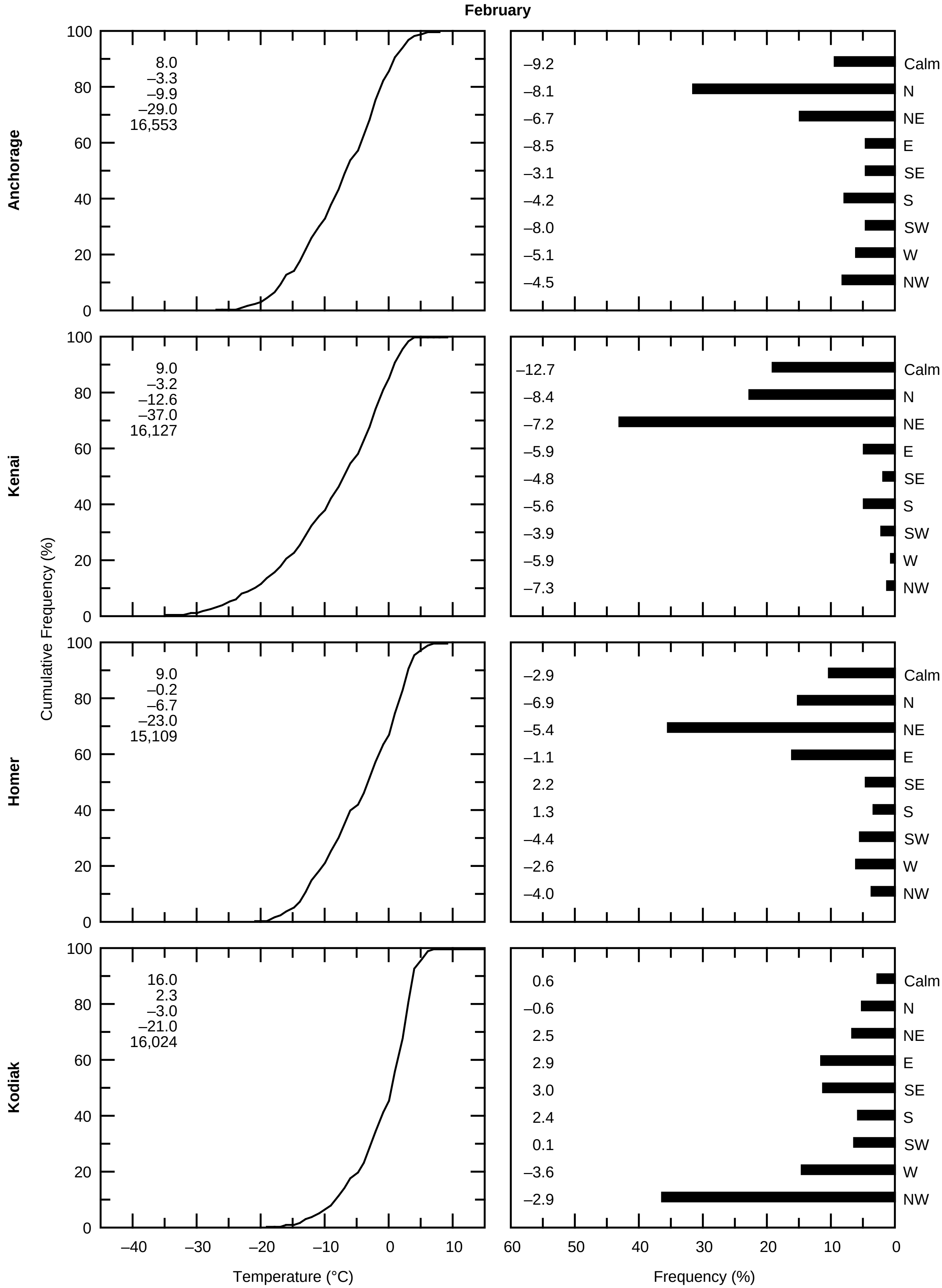
Figure C1. Cook Inlet Ice GIS Analysis Process

APPENDIX D: AIR TEMPERATURE

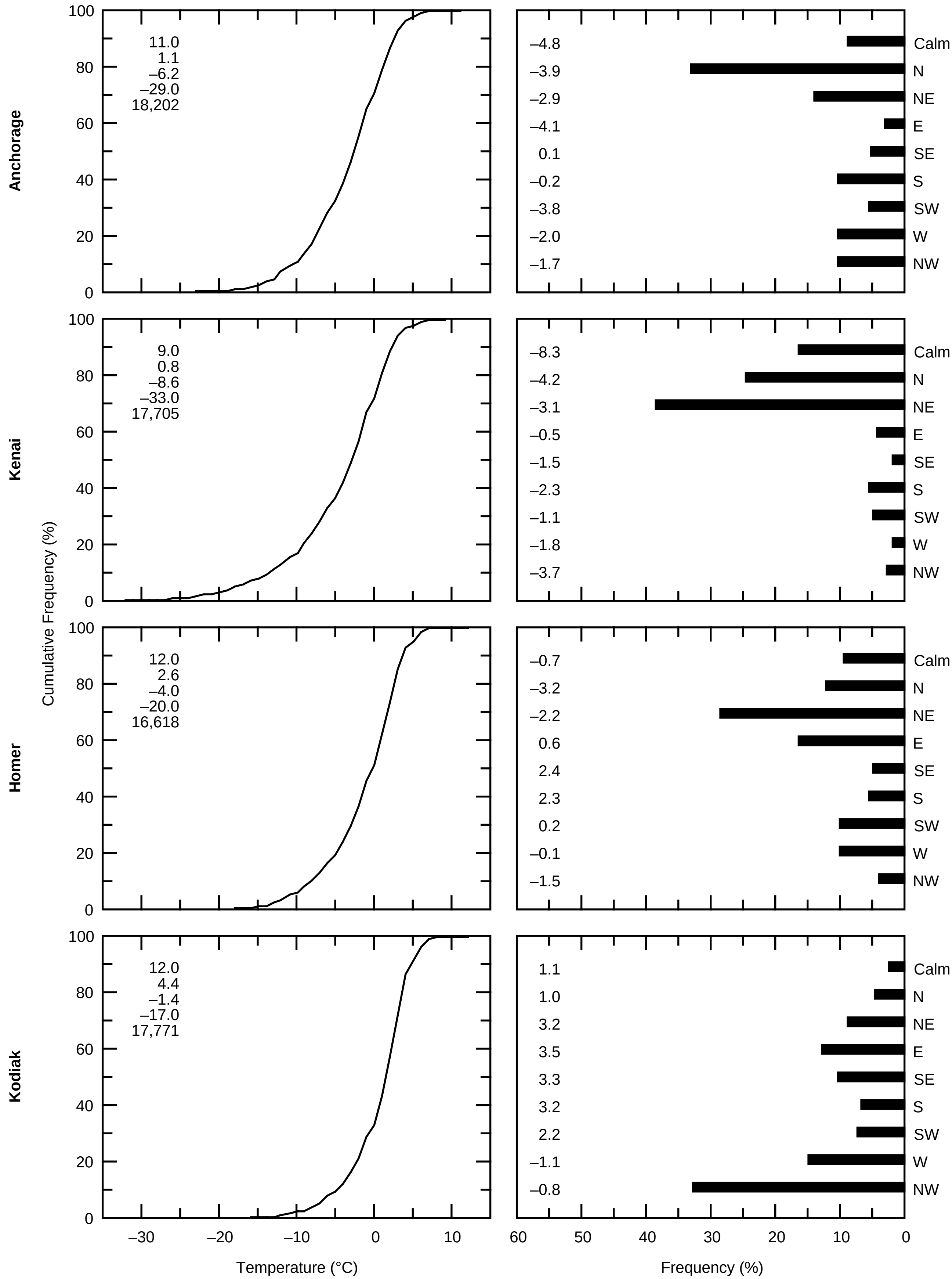
The graphs shown on the following pages represent the air temperature regimes at Anchorage, Kenai, Homer, and Kodiak, Alaska, for each month of the year. The data were assembled and summarized specifically for this project by the Air Force Combat Climatology Center as described in Section 6.1 (Source and Description of Climatological Data for Cook Inlet). The first graph shown for each month is a cumulative percent frequency distribution of air temperatures equal to or less than the temperature shown on the horizontal axis for all observations throughout the period of record, Jan. 1973–Dec. 1997 (except Jan. 1973–Oct. 1997 for Homer). The values in the upper left corner of the graph are the POR extreme maximum and minimum air temperatures, the mean monthly maximum and minimum temperatures, and the total number of observations comprising that month's distribution of temperatures. The second graph (in bar-chart form) shows the mean air temperature associated with winds from each compass direction and for calm winds.

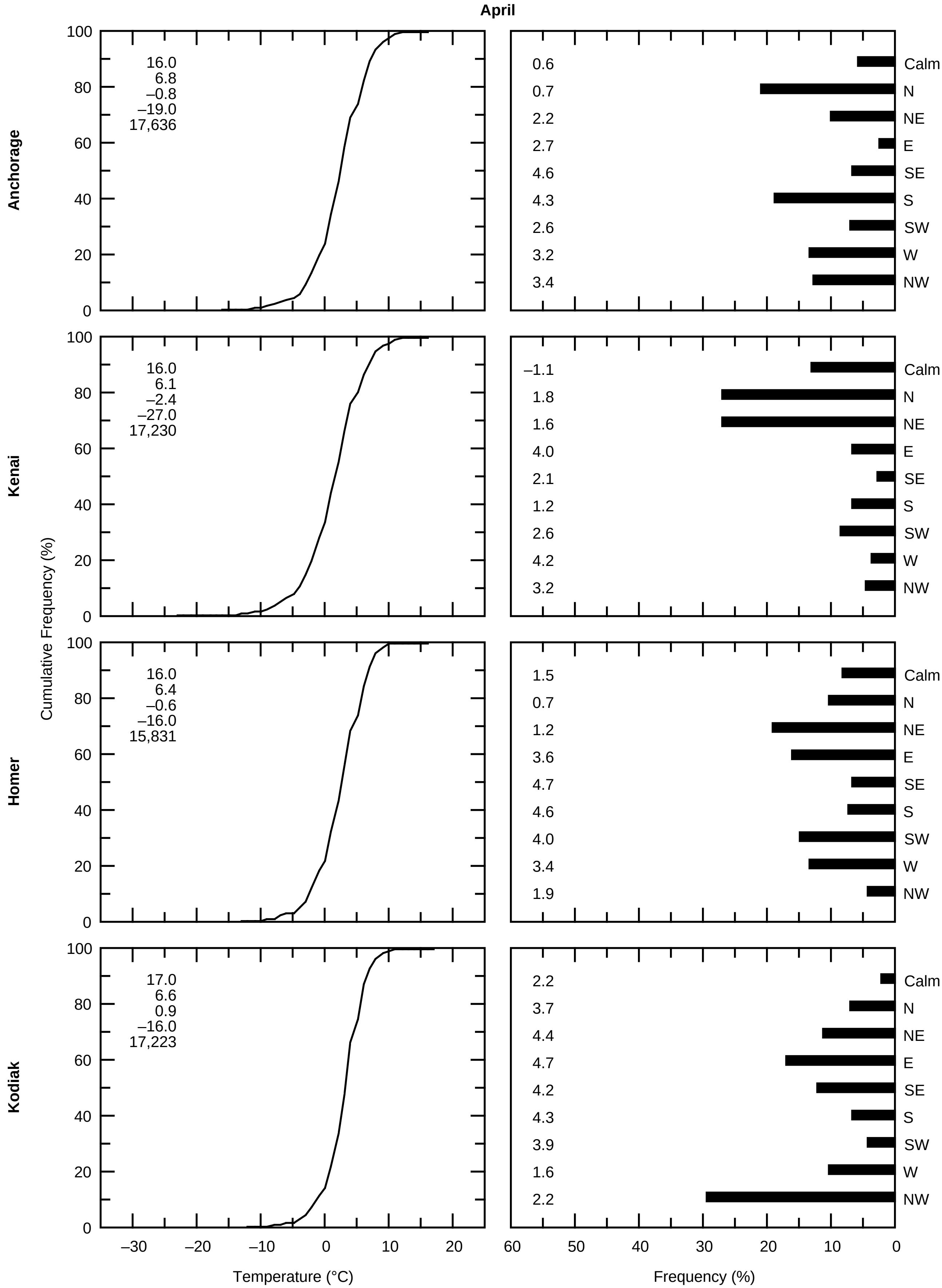



January
Anchorage
9.0
–4.8
–10.8
–34.0
18,153
–12.2 Calm
–8.8 N
–7.4 NE
–10.5 E
–4.4 SE
–2.9 S
–8.8 SW
–5.8 W
–5.1 NW
Kenai
11.0
–5.1
–13.1
–43.0
17,346
–16.3 Calm
–10.2 N
–6.4 NE
–4.7 E
–3.7 SE
–3.5 S
–2.0 SW
–4.6 W
–11.6 NW
Homer
13.0
–0.9
–6.4
–31.0
16,518
–3.5 Calm
–7.5 N
–5.1 NE
0.3 E
2.8 SE
2.1 S
–3.1 SW
–1.9 W
–4.4 NW
Kodiak
11.0
2.4
–2.2
–26.0
17,307
0.2 Calm
–0.7 N
3.2 NE
3.7 E
3.6 SE
2.9 S
0.9 SW
–3.0 W
–2.6 NW
Cumulative Frequency (%)
0 20 40 60 80 100
–40 –30 –20 –10 0 10
Temperature (°C)
60 50 40 30 20 10 0
Frequency (%)


February
Anchorage
8.0
–3.3
–9.9
–29.0
16,553
–9.2 Calm
–8.1 N
–6.7 NE
–8.5 E
–3.1 SE
–4.2 S
–8.0 SW
–5.1 W
–4.5 NW
Kenai
9.0
–3.2
–12.6
–37.0
16,127
–12.7 Calm
–8.4 N
–7.2 NE
–5.9 E
–4.8 SE
–5.6 S
–3.9 SW
–5.9 W
–7.3 NW
Homer
9.0
–0.2
–6.7
–23.0
15,109
–2.9 Calm
–6.9 N
–5.4 NE
–1.1 E
2.2 SE
1.3 S
–4.4 SW
–2.6 W
–4.0 NW
Kodiak
16.0
2.3
–3.0
–21.0
16,024
0.6 Calm
–0.6 N
2.5 NE
2.9 E
3.0 SE
2.4 S
0.1 SW
–3.6 W
–2.9 NW
Cumulative Frequency (%)
Temperature (°C)
Frequency (%)

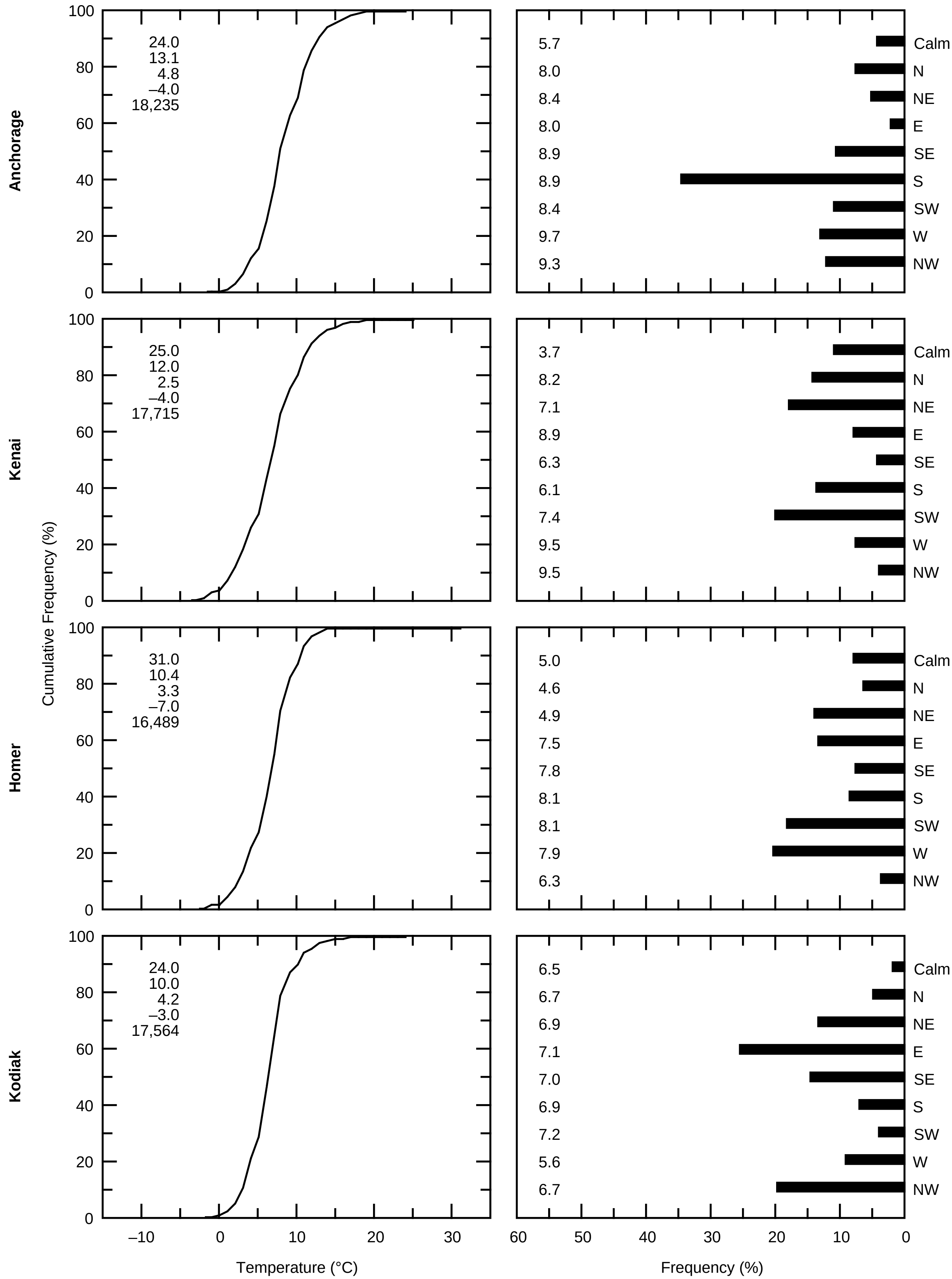
March


Anchorage
11.0
1.1
–6.2
–29.0
18,202
–4.8 Calm
–3.9 N
–2.9 NE
–4.1 E
0.1 SE
–0.2 S
–3.8 SW
–2.0 W
–1.7 NW
Kenai
9.0
0.8
–8.6
–33.0
17,705
–8.3 Calm
–4.2 N
–3.1 NE
–0.5 E
–1.5 SE
–2.3 S
–1.1 SW
–1.8 W
–3.7 NW
Homer
12.0
2.6
–4.0
–20.0
16,618
–0.7 Calm
–3.2 N
–2.2 NE
0.6 E
2.4 SE
2.3 S
0.2 SW
–0.1 W
–1.5 NW
Kodiak
12.0
4.4
–1.4
–17.0
17,771
1.1 Calm
1.0 N
3.2 NE
3.5 E
3.3 SE
3.2 S
2.2 SW
–1.1 W
–0.8 NW
Cumulative Frequency (%)
Temperature (°C)
Frequency (%)

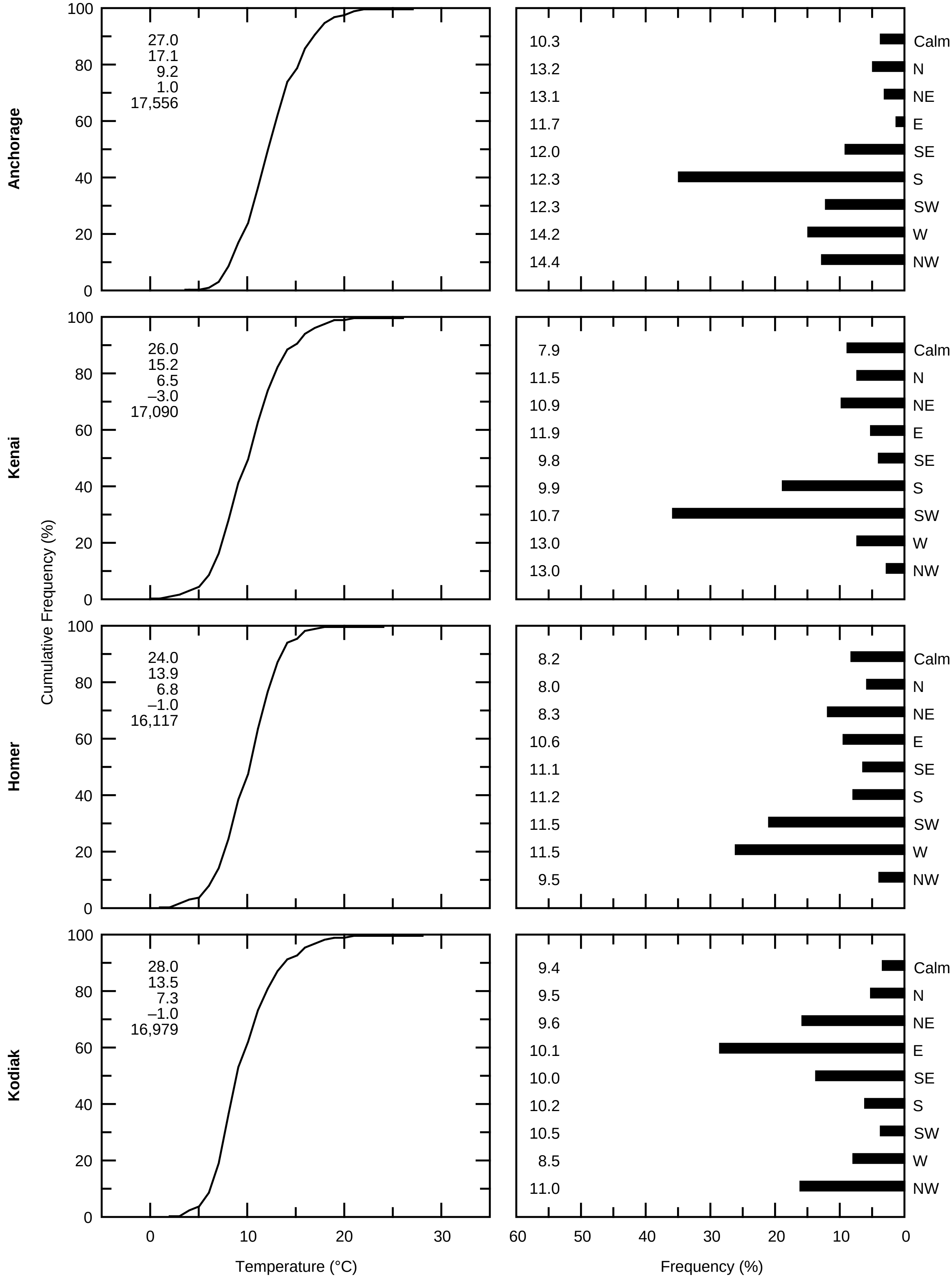


April
Anchorage
16.0
6.8
–0.8
–19.0
17,636
0.6 Calm
0.7 N
2.2 NE
2.7 E
4.6 SE
4.3 S
2.6 SW
3.2 W
3.4 NW
Kenai
16.0
6.1
–2.4
–27.0
17,230
–1.1 Calm
1.8 N
1.6 NE
4.0 E
2.1 SE
1.2 S
2.6 SW
4.2 W
3.2 NW
Homer
16.0
6.4
–0.6
–16.0
15,831
1.5 Calm
0.7 N
1.2 NE
3.6 E
4.7 SE
4.6 S
4.0 SW
3.4 W
1.9 NW
Kodiak
17.0
6.6
0.9
–16.0
17,223
2.2 Calm
3.7 N
4.4 NE
4.7 E
4.2 SE
4.3 S
3.9 SW
1.6 W
2.2 NW
Cumulative Frequency (%)
Temperature (°C)
Frequency (%)

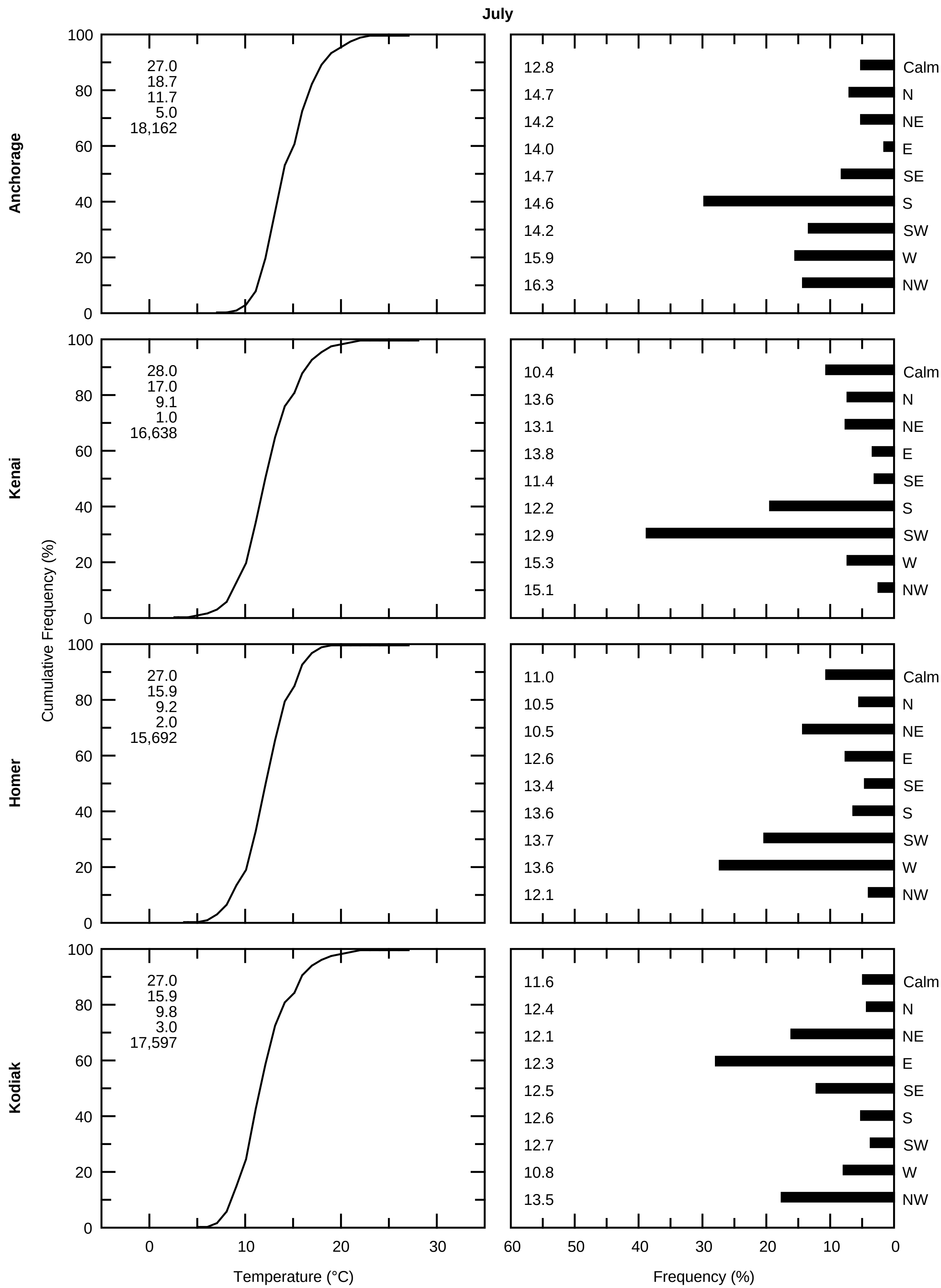
May

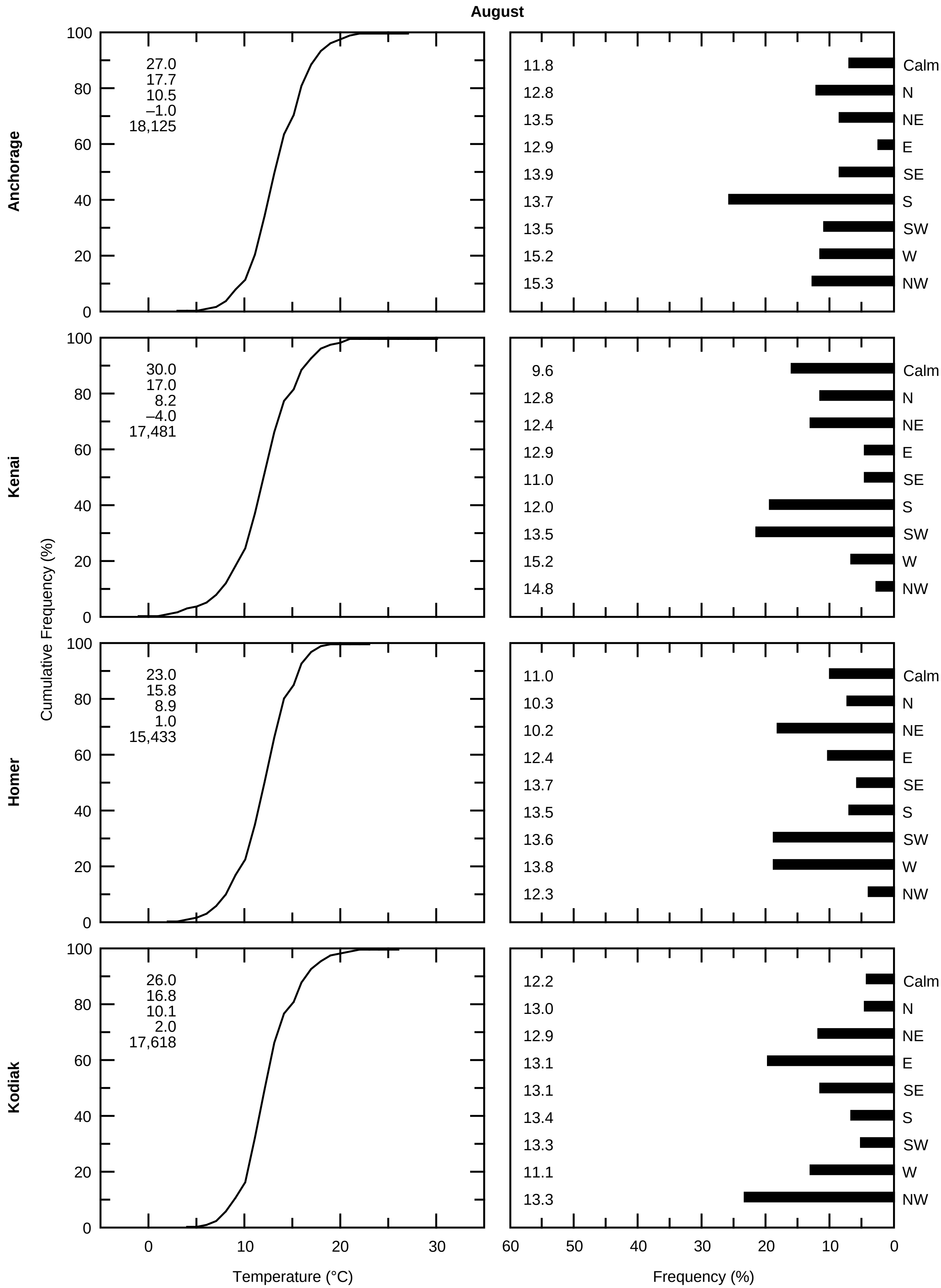

Anchorage
24.0
13.1
4.8
–4.0
18,235
5.7 Calm
8.0 N
8.4 NE
8.0 E
8.9 SE
8.9 S
8.4 SW
9.7 W
9.3 NW
Kenai
25.0
12.0
2.5
–4.0
17,715
3.7 Calm
8.2 N
7.1 NE
8.9 E
6.3 SE
6.1 S
7.4 SW
9.5 W
9.5 NW
Homer
31.0
10.4
3.3
–7.0
16,489
5.0 Calm
4.6 N
4.9 NE
7.5 E
7.8 SE
8.1 S
8.1 SW
7.9 W
6.3 NW
Kodiak
24.0
10.0
4.2
–3.0
17,564
6.5 Calm
6.7 N
6.9 NE
7.1 E
7.0 SE
6.9 S
7.2 SW
5.6 W
6.7 NW
Cumulative Frequency (%)
0
20
40
60
80
100
–10
0
10
20
30
Temperature (°C)
60
50
40
30
20
10
0
Frequency (%)

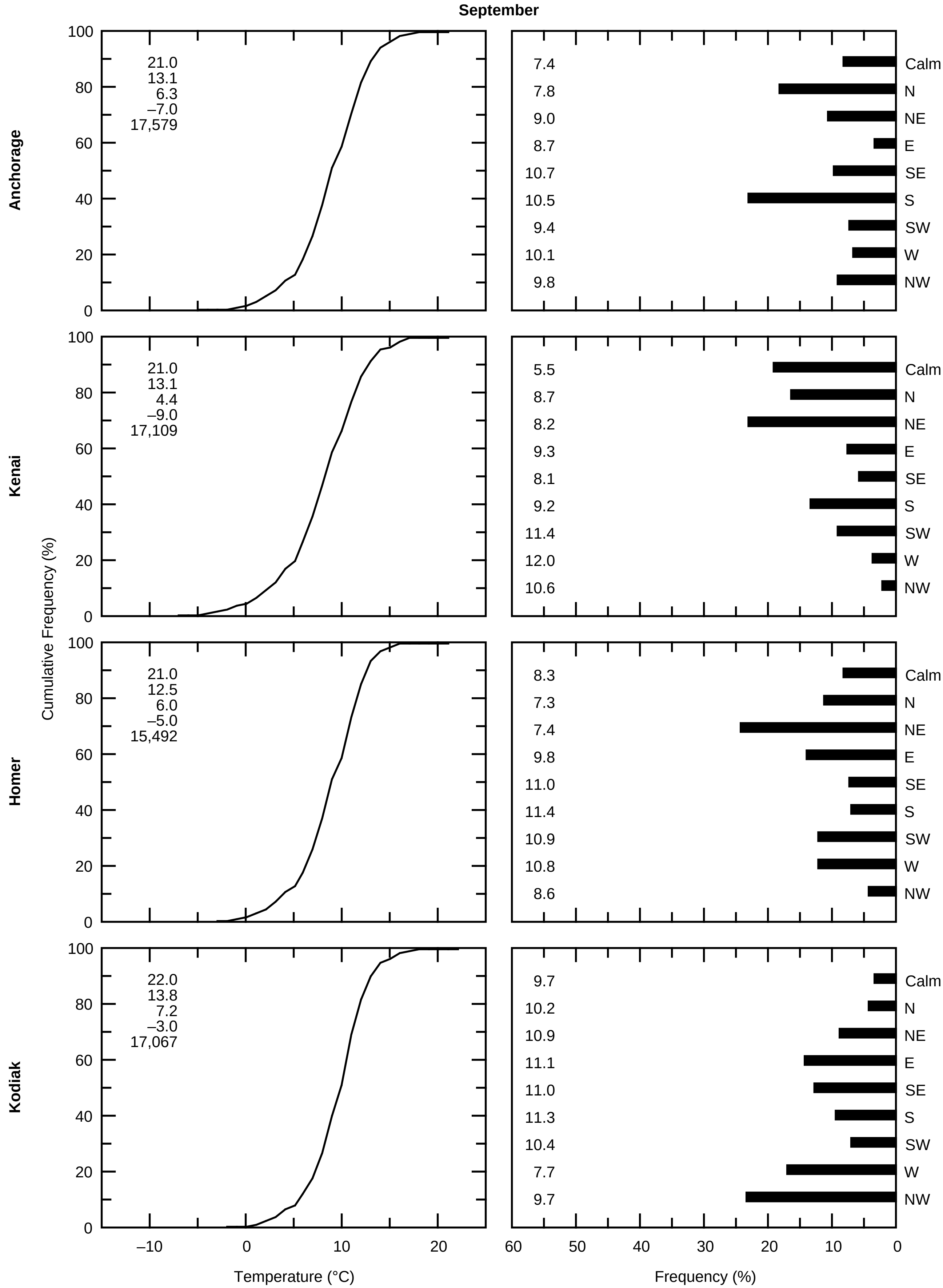
June



Anchorage
27.0
17.1
9.2
1.0
17,556
10.3 Calm
13.2 N
13.1 NE
11.7 E
12.0 SE
12.3 S
12.3 SW
14.2 W
14.4 NW
Kenai
26.0
15.2
6.5
–3.0
17,090
7.9 Calm
11.5 N
10.9 NE
11.9 E
9.8 SE
9.9 S
10.7 SW
13.0 W
13.0 NW
Homer
24.0
13.9
6.8
–1.0
16,117
8.2 Calm
8.0 N
8.3 NE
10.6 E
11.1 SE
11.2 S
11.5 SW
11.5 W
9.5 NW
Kodiak
28.0
13.5
7.3
–1.0
16,979
9.4 Calm
9.5 N
9.6 NE
10.1 E
10.0 SE
10.2 S
10.5 SW
8.5 W
11.0 NW
Cumulative Frequency (%)
0 20 40 60 80 100
0 10 20 30
Temperature (°C)
60 50 40 30 20 10 0
Frequency (%)

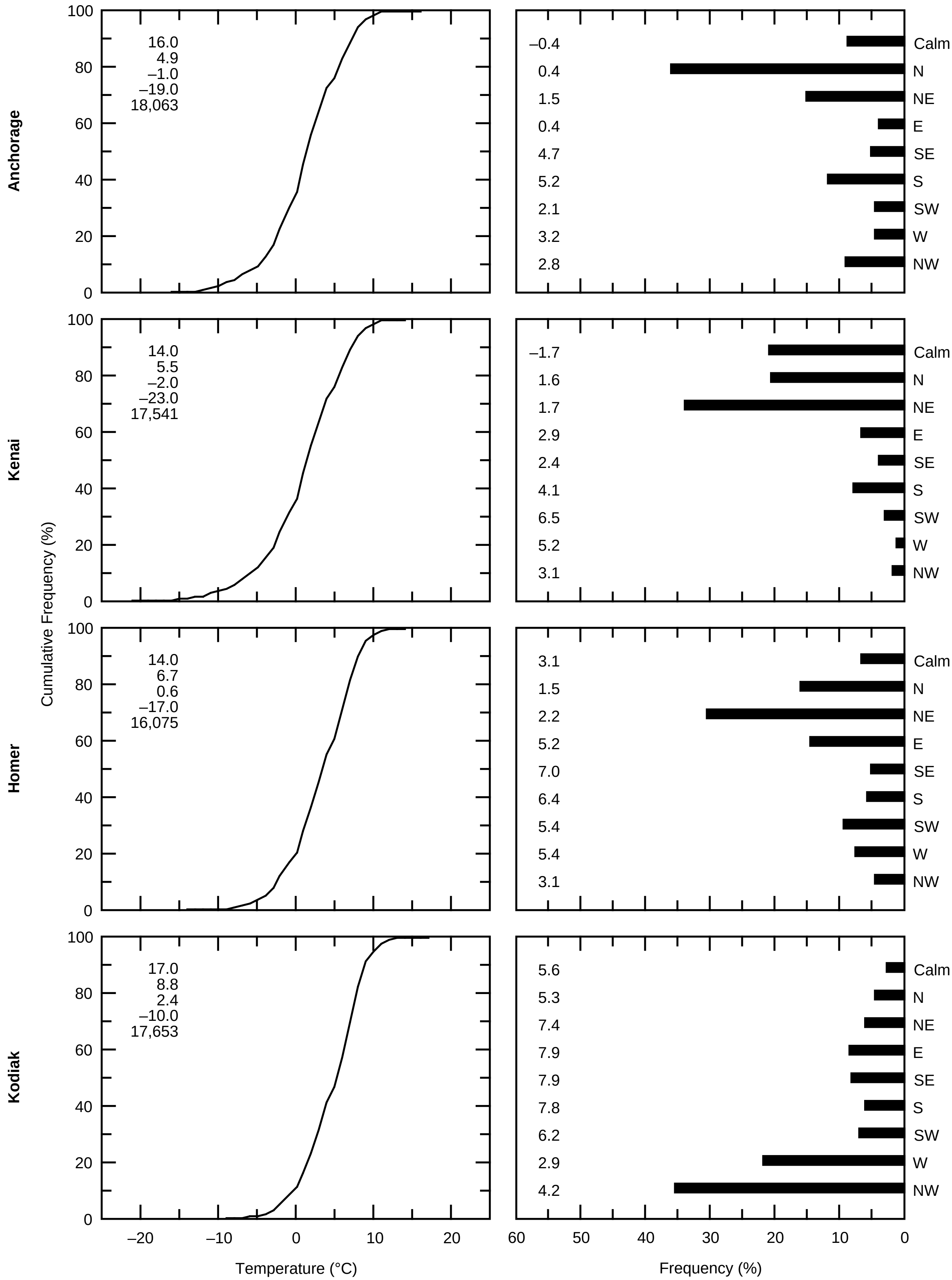

July
Anchorage
27.0
18.7
11.7
5.0
18,162
12.8 Calm
14.7 N
14.2 NE
14.0 E
14.7 SE
14.6 S
14.2 SW
15.9 W
16.3 NW
Kenai
28.0
17.0
9.1
1.0
16,638
10.4 Calm
13.6 N
13.1 NE
13.8 E
11.4 SE
12.2 S
12.9 SW
15.3 W
15.1 NW
Homer
27.0
15.9
9.2
2.0
15,692
11.0 Calm
10.5 N
10.5 NE
12.6 E
13.4 SE
13.6 S
13.7 SW
13.6 W
12.1 NW
Kodiak
27.0
15.9
9.8
3.0
17,597
11.6 Calm
12.4 N
12.1 NE
12.3 E
12.5 SE
12.6 S
12.7 SW
10.8 W
13.5 NW
Cumulative Frequency (%)
Temperature (°C)
Frequency (%)


August
Anchorage
27.0
17.7
10.5
–1.0
18,125
11.8 Calm
12.8 N
13.5 NE
12.9 E
13.9 SE
13.7 S
13.5 SW
15.2 W
15.3 NW
Kenai
30.0
17.0
8.2
–4.0
17,481
9.6 Calm
12.8 N
12.4 NE
12.9 E
11.0 SE
12.0 S
13.5 SW
15.2 W
14.8 NW
Homer
23.0
15.8
8.9
1.0
15,433
11.0 Calm
10.3 N
10.2 NE
12.4 E
13.7 SE
13.5 S
13.6 SW
13.8 W
12.3 NW
Kodiak
26.0
16.8
10.1
2.0
17,618
12.2 Calm
13.0 N
12.9 NE
13.1 E
13.1 SE
13.4 S
13.3 SW
11.1 W
13.3 NW
Cumulative Frequency (%)
0
20
40
60
80
100
Temperature (°C)
0
10
20
30
Frequency (%)
60
50
40
30
20
10
0

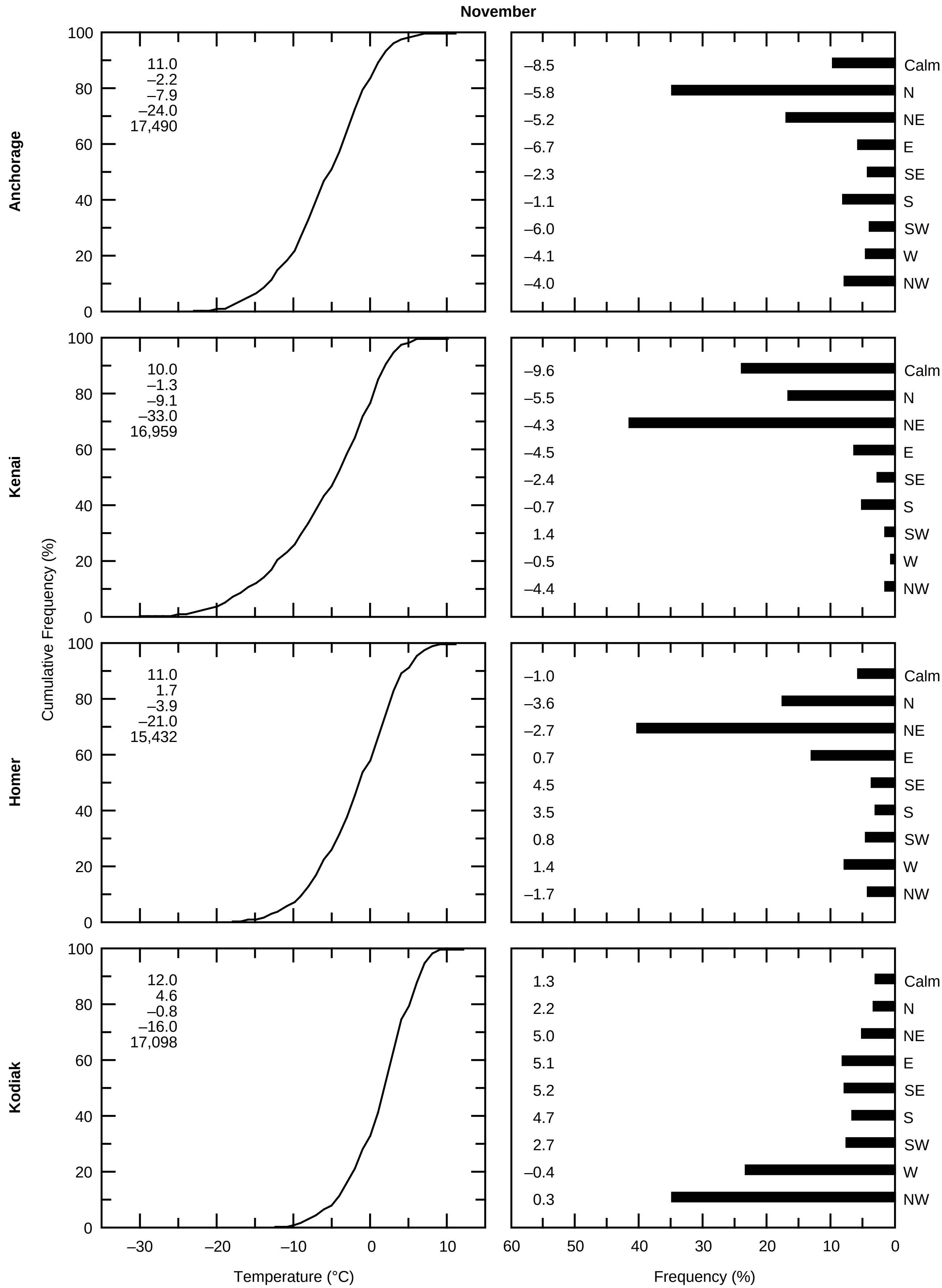


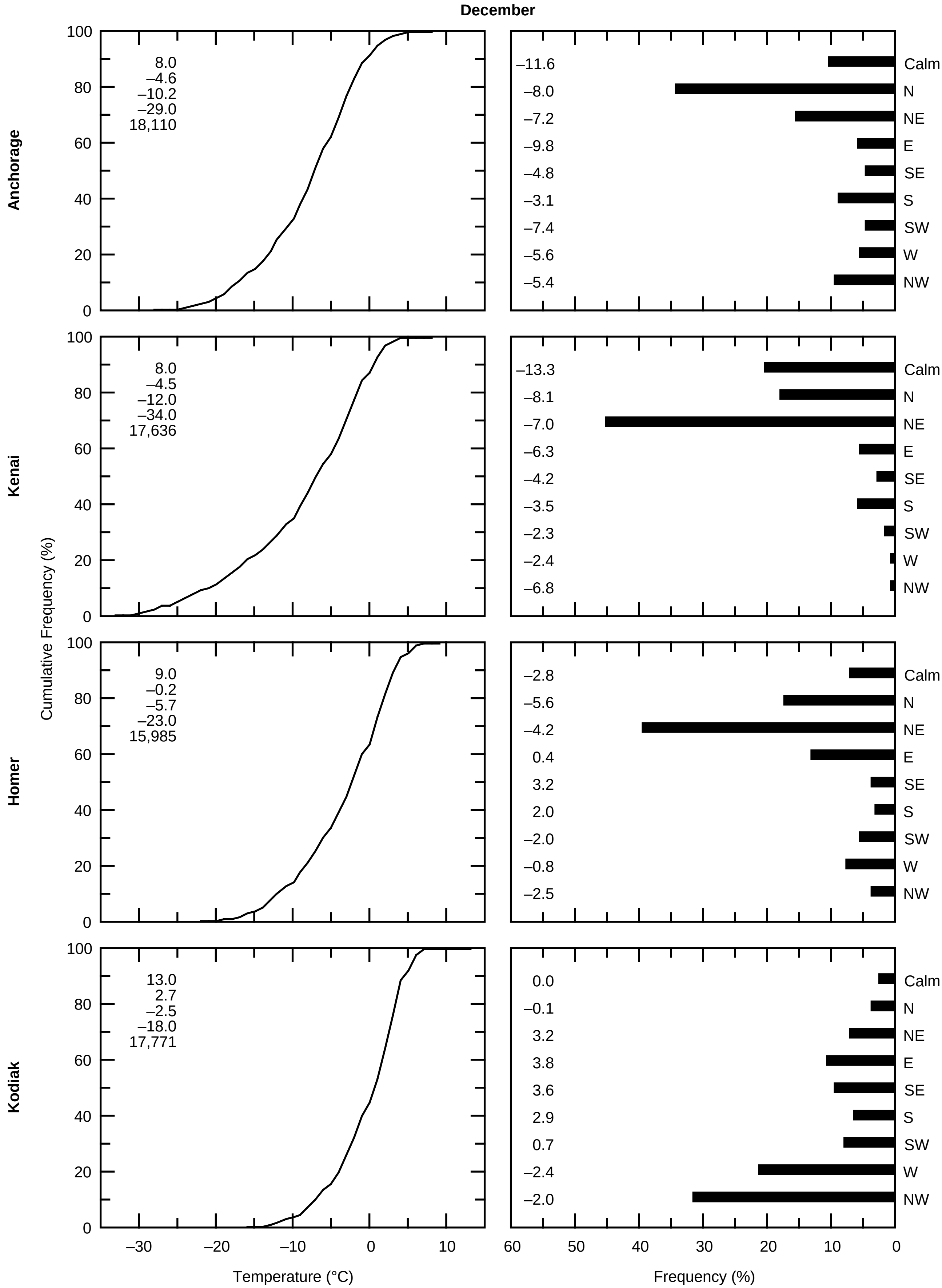
September
Anchorage
21.0
13.1
6.3
–7.0
17,579
7.4 Calm
7.8 N
9.0 NE
8.7 E
10.7 SE
10.5 S
9.4 SW
10.1 W
9.8 NW
Kenai
21.0
13.1
4.4
–9.0
17,109
5.5 Calm
8.7 N
8.2 NE
9.3 E
8.1 SE
9.2 S
11.4 SW
12.0 W
10.6 NW
Homer
21.0
12.5
6.0
–5.0
15,492
8.3 Calm
7.3 N
7.4 NE
9.8 E
11.0 SE
11.4 S
10.9 SW
10.8 W
8.6 NW
Kodiak
22.0
13.8
7.2
–3.0
17,067
9.7 Calm
10.2 N
10.9 NE
11.1 E
11.0 SE
11.3 S
10.4 SW
7.7 W
9.7 NW
Cumulative Frequency (%)
Temperature (°C)
Frequency (%)

October



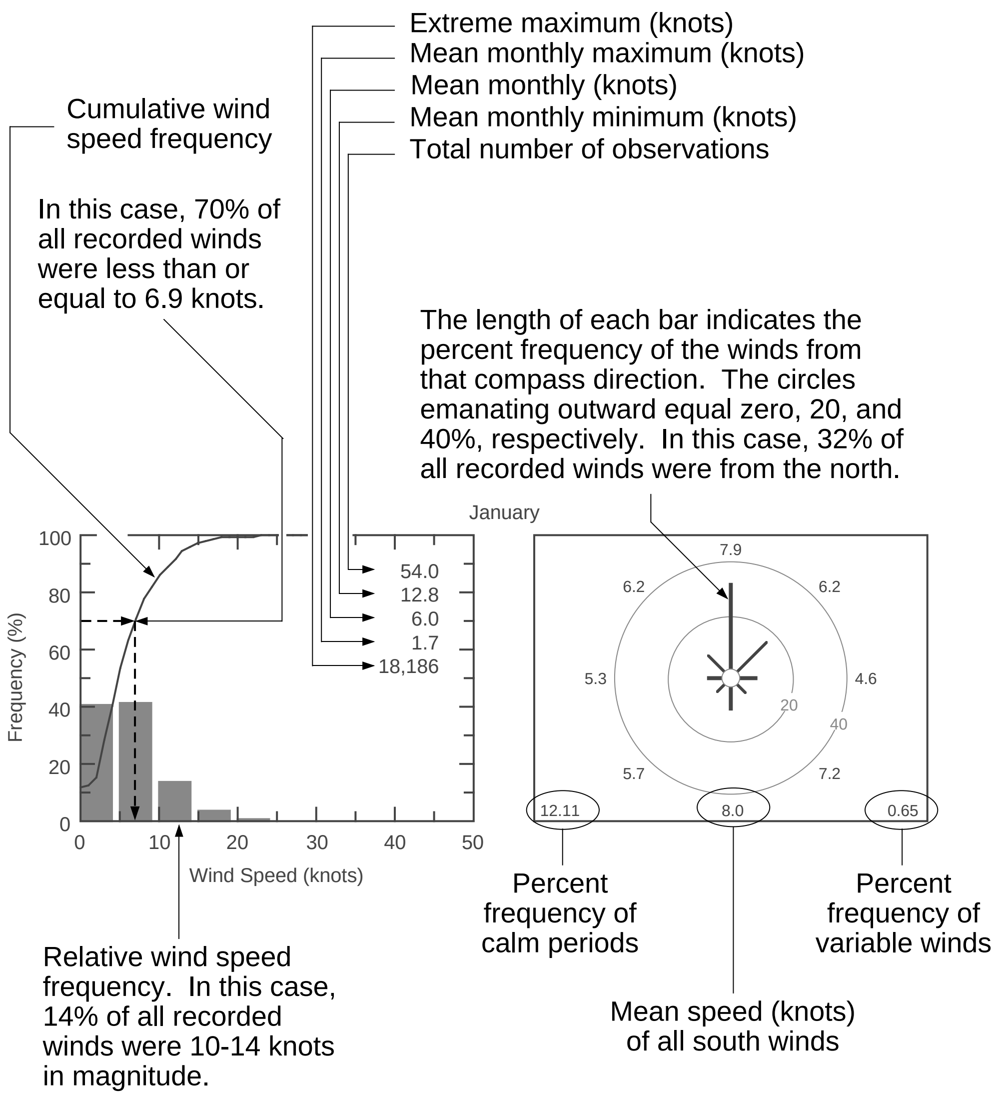
Anchorage
16.0
4.9
–1.0
–19.0
18,063
–0.4 Calm
0.4 N
1.5 NE
0.4 E
4.7 SE
5.2 S
2.1 SW
3.2 W
2.8 NW
Kenai
14.0
5.5
–2.0
–23.0
17,541
–1.7 Calm
1.6 N
1.7 NE
2.9 E
2.4 SE
4.1 S
6.5 SW
5.2 W
3.1 NW
Homer
14.0
6.7
0.6
–17.0
16,075
3.1 Calm
1.5 N
2.2 NE
5.2 E
7.0 SE
6.4 S
5.4 SW
5.4 W
3.1 NW
Kodiak
17.0
8.8
2.4
–10.0
17,653
5.6 Calm
5.3 N
7.4 NE
7.9 E
7.9 SE
7.8 S
6.2 SW
2.9 W
4.2 NW
Cumulative Frequency (%)
Temperature (°C)
Frequency (%)


November
Anchorage
11.0
–2.2
–7.9
–24.0
17,490
–8.5 Calm
–5.8 N
–5.2 NE
–6.7 E
–2.3 SE
–1.1 S
–6.0 SW
–4.1 W
–4.0 NW
Kenai
10.0
–1.3
–9.1
–33.0
16,959
–9.6 Calm
–5.5 N
–4.3 NE
–4.5 E
–2.4 SE
–0.7 S
1.4 SW
–0.5 W
–4.4 NW
Homer
11.0
1.7
–3.9
–21.0
15,432
–1.0 Calm
–3.6 N
–2.7 NE
0.7 E
4.5 SE
3.5 S
0.8 SW
1.4 W
–1.7 NW
Kodiak
12.0
4.6
–0.8
–16.0
17,098
1.3 Calm
2.2 N
5.0 NE
5.1 E
5.2 SE
4.7 S
2.7 SW
–0.4 W
0.3 NW
Cumulative Frequency (%)
0
20
40
60
80
100
–30
–20
–10
0
10
Temperature (°C)
60
50
40
30
20
10
0
Frequency (%)

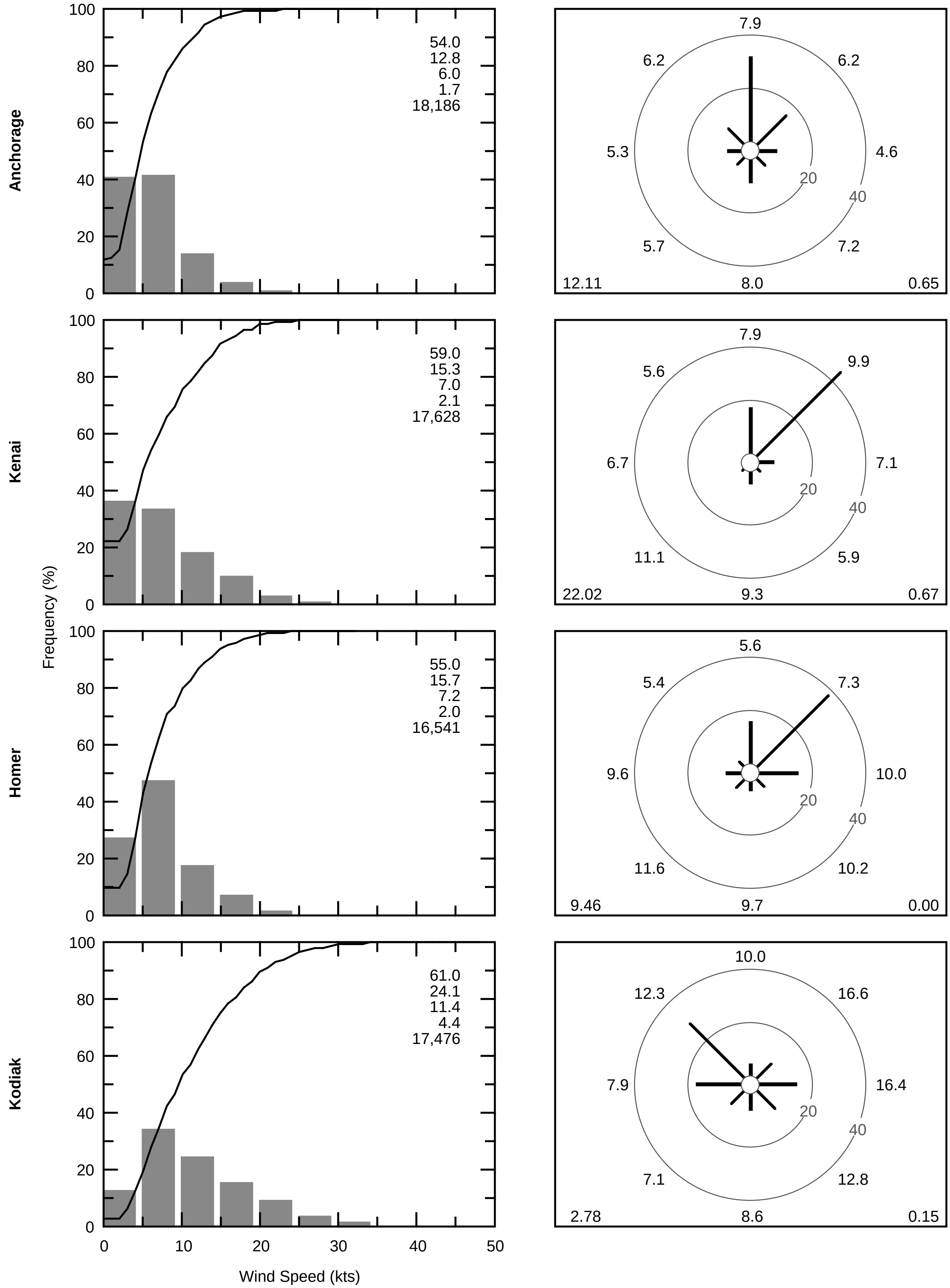

December
Anchorage
Kenai
Homer
Kodiak
Cumulative Frequency (%)
8.0
–4.6
–10.2
–29.0
18,110
8.0
–4.5
–12.0
–34.0
17,636
9.0
–0.2
–5.7
–23.0
15,985
13.0
2.7
–2.5
–18.0
17,771
–11.6 Calm
–8.0 N
–7.2 NE
–9.8 E
–4.8 SE
–3.1 S
–7.4 SW
–5.6 W
–5.4 NW
–13.3 Calm
–8.1 N
–7.0 NE
–6.3 E
–4.2 SE
–3.5 S
–2.3 SW
–2.4 W
–6.8 NW
–2.8 Calm
–5.6 N
–4.2 NE
0.4 E
3.2 SE
2.0 S
–2.0 SW
–0.8 W
–2.5 NW
0.0 Calm
–0.1 N
3.2 NE
3.8 E
3.6 SE
2.9 S
0.7 SW
–2.4 W
–2.0 NW
Temperature (°C)
Frequency (%)

APPENDIX E: WIND

The wind speed and wind direction regimes for Anchorage, Kenai, Homer, and Kodiak, Alaska, are shown. These data were assembled and summarized specifically for this project by the Air Force Combat Climatology Center as described in Section 6.1 (Source and Description of Climatological Data for Cook Inlet) from hourly observations of the mean wind speed for the period of record Jan. 1973–Dec. 1997 (except Jan. 1973–Oct. 1997 for Homer). Gust winds are not included (when gust winds were included, the mean wind speeds increased approximately 5% at Anchorage, Homer, and Kenai and 11% at Kodiak). The graphs on the left side of the page show the cumulative frequency distribution (line) with respect to wind speed and the distribution of individual speed categories (bars), in 5-knot increments (0–4, 5–9, 10–14 knots, etc). The monthly summary statistics are shown in the upper right corner of the plots. The graphs on the right are "wind roses" showing the frequency occurrence of winds from each direction of the compass. The length of the line radiating from the center circle corresponds to how frequently (in percent of all observations) the wind originates from that particular direction. The values on the perimeter of the outer circle are the mean speeds of the winds from the indicated direction.

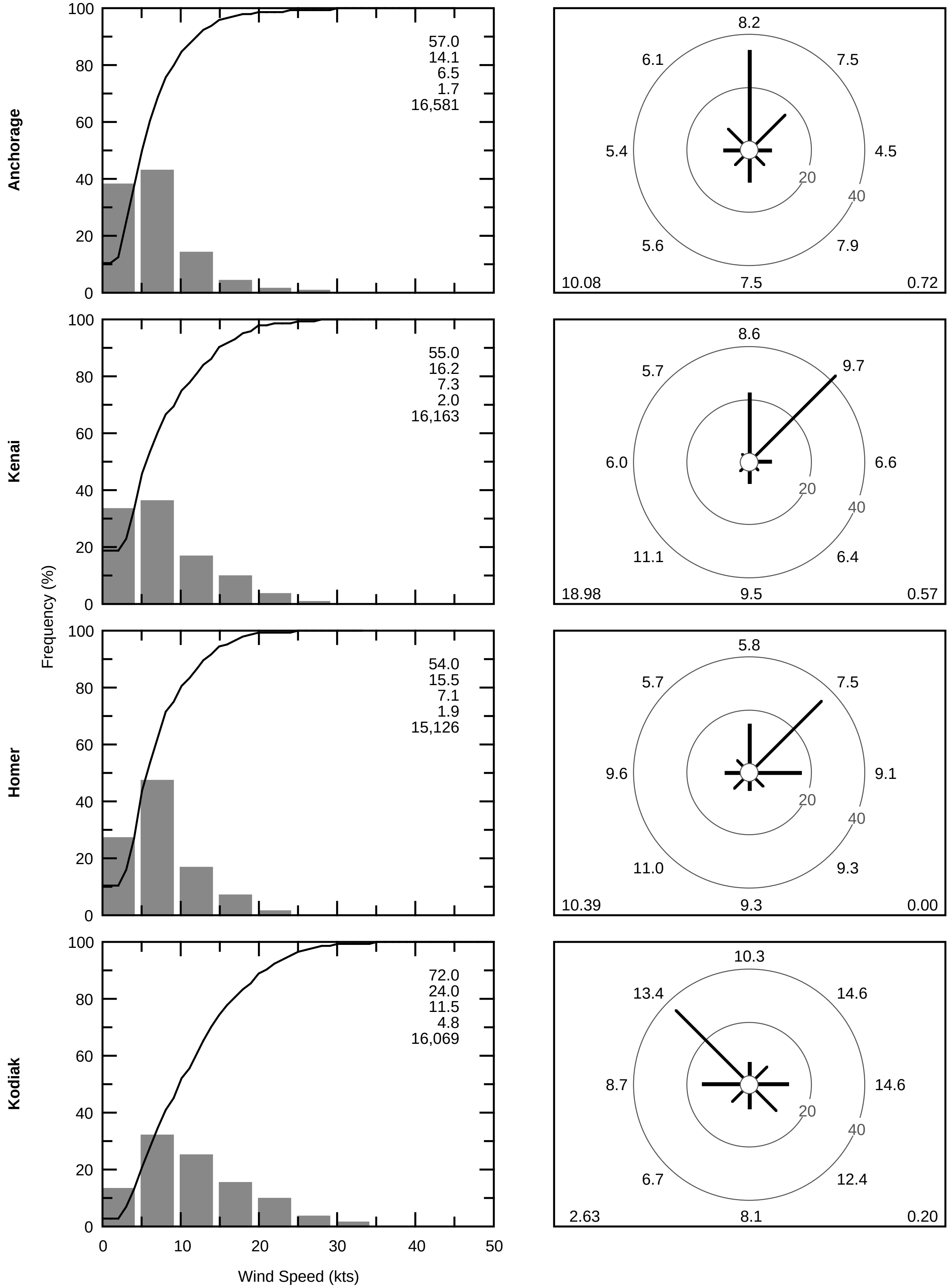


January

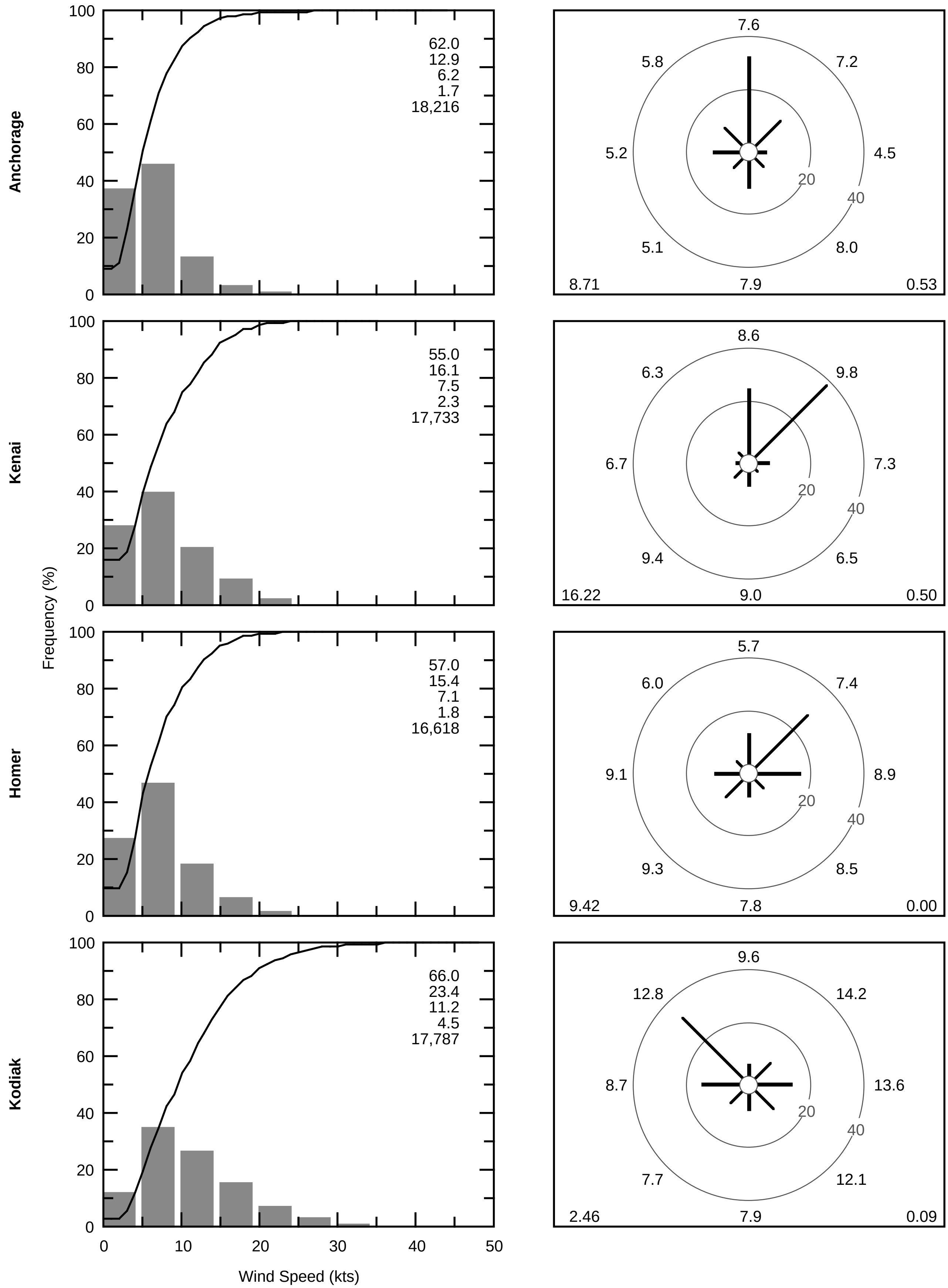


Anchorage
54.0
12.8
6.0
1.7
18,186
7.9
6.2
6.2
5.3
4.6
20
40
5.7
7.2
12.11
8.0
0.65
Kenai
59.0
15.3
7.0
2.1
17,628
7.9
5.6
9.9
6.7
7.1
11.1
5.9
22.02
9.3
0.67
Homer
55.0
15.7
7.2
2.0
16,541
5.6
5.4
7.3
9.6
10.0
11.6
10.2
9.46
9.7
0.00
Kodiak
61.0
24.1
11.4
4.4
17,476
10.0
12.3
16.6
7.9
16.4
7.1
12.8
2.78
8.6
0.15
Frequency (%)
0
20
40
60
80
100
0
10
20
30
40
50
Wind Speed (kts)

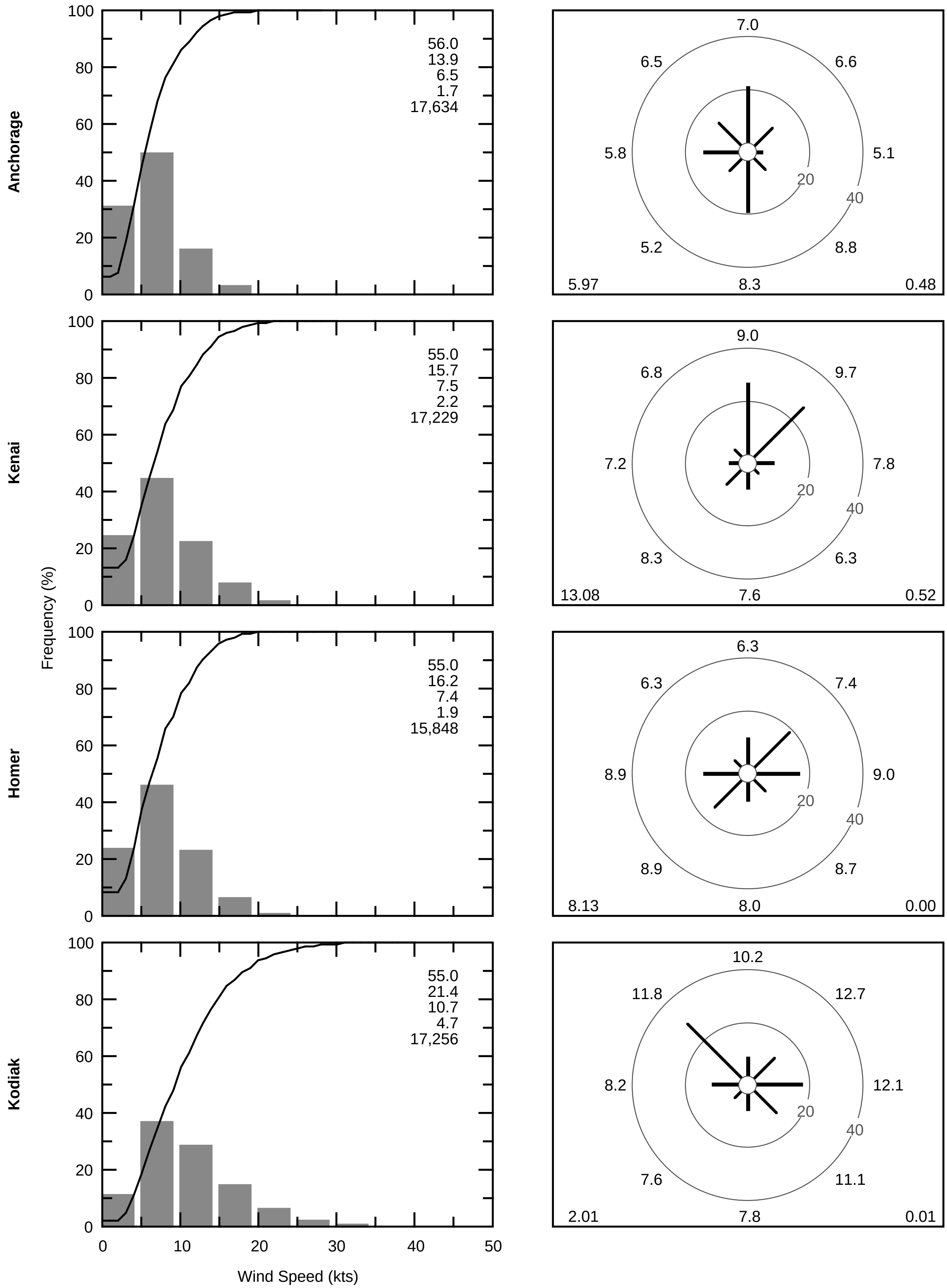
February


Anchorage
57.0
14.1
6.5
1.7
16,581
8.2
6.1
7.5
5.4
4.5
5.6
7.9
7.5
10.08
0.72
Kenai
55.0
16.2
7.3
2.0
16,163
8.6
5.7
9.7
6.0
6.6
11.1
6.4
9.5
18.98
0.57
Homer
54.0
15.5
7.1
1.9
15,126
5.8
5.7
7.5
9.6
9.1
11.0
9.3
9.3
10.39
0.00
Kodiak
72.0
24.0
11.5
4.8
16,069
10.3
13.4
14.6
8.7
14.6
6.7
12.4
8.1
2.63
0.20
20
40
Frequency (%)
0
20
40
60
80
100
0
10
20
30
40
50
Wind Speed (kts)

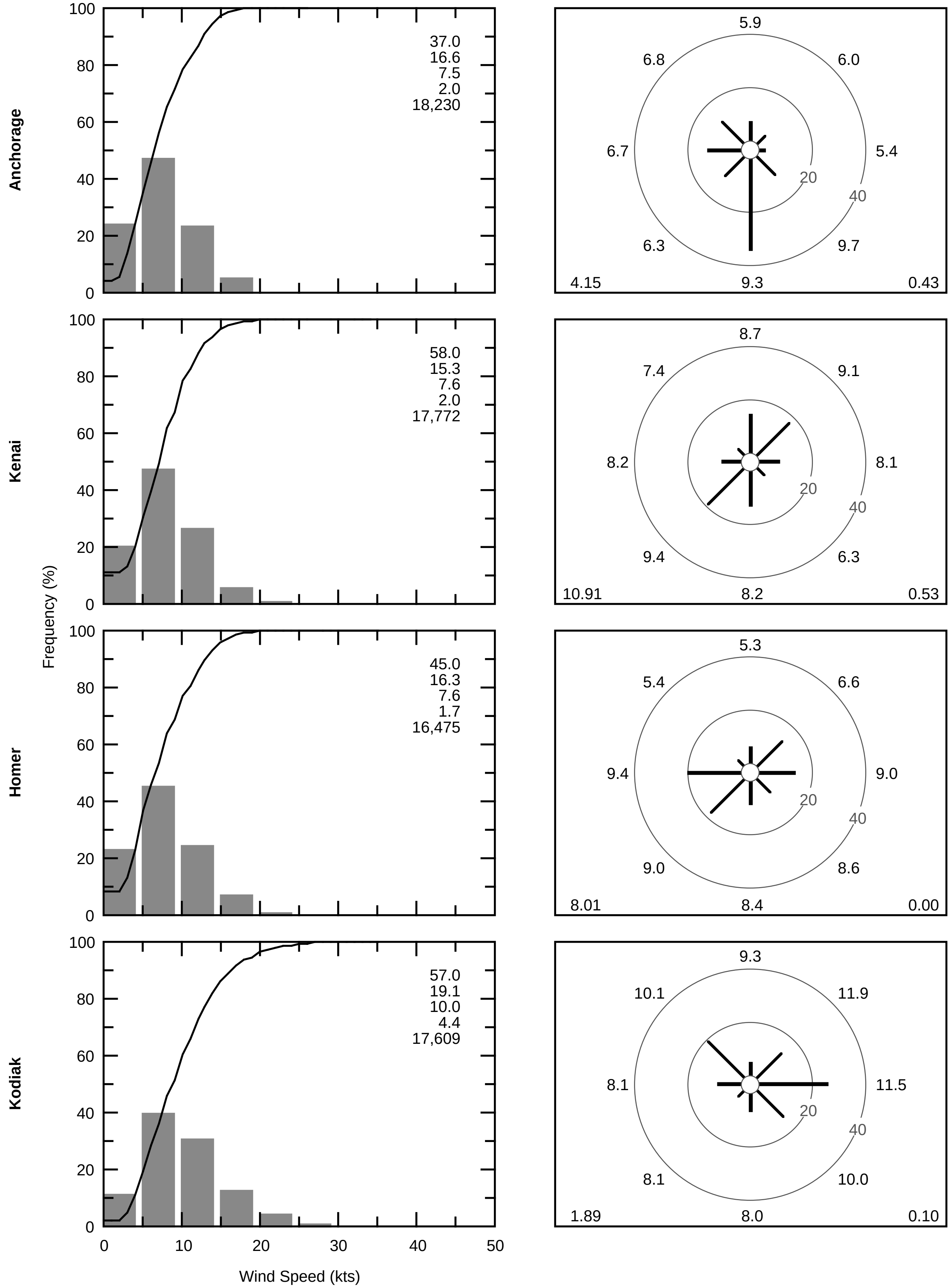
March


Anchorage
Kenai
Homer
Kodiak
Frequency (%)
Wind Speed (kts)
0
10
20
30
40
50
100
80
60
40
20
0
62.0
12.9
6.2
1.7
18,216
55.0
16.1
7.5
2.3
17,733
57.0
15.4
7.1
1.8
16,618
66.0
23.4
11.2
4.5
17,787
7.6
5.8
7.2
5.2
4.5
5.1
8.0
7.9
8.71
0.53
8.6
6.3
9.8
6.7
7.3
9.4
6.5
9.0
16.22
0.50
5.7
6.0
7.4
9.1
8.9
9.3
8.5
7.8
9.42
0.00
9.6
12.8
14.2
8.7
13.6
7.7
12.1
7.9
2.46
0.09
20
40

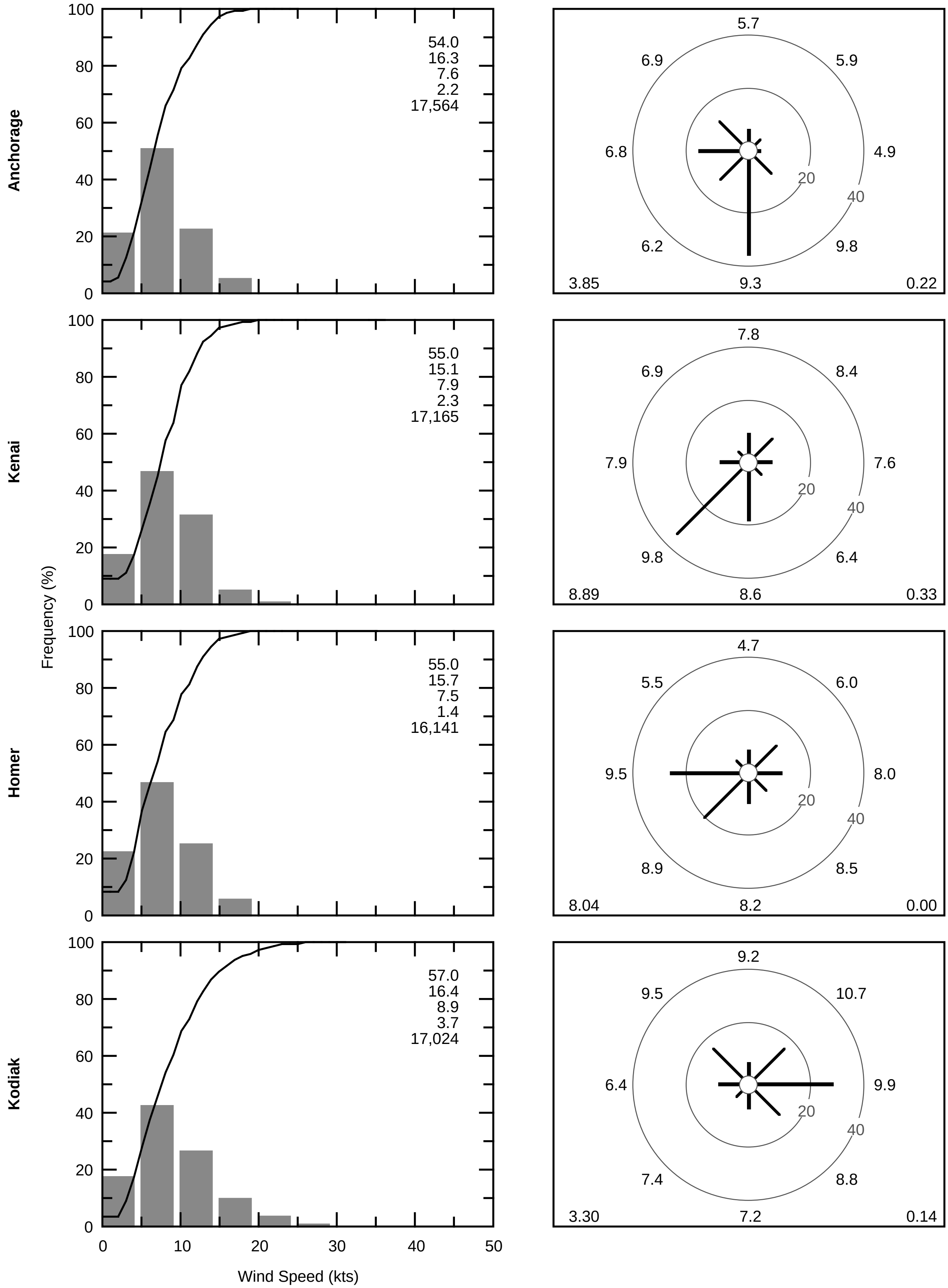
April

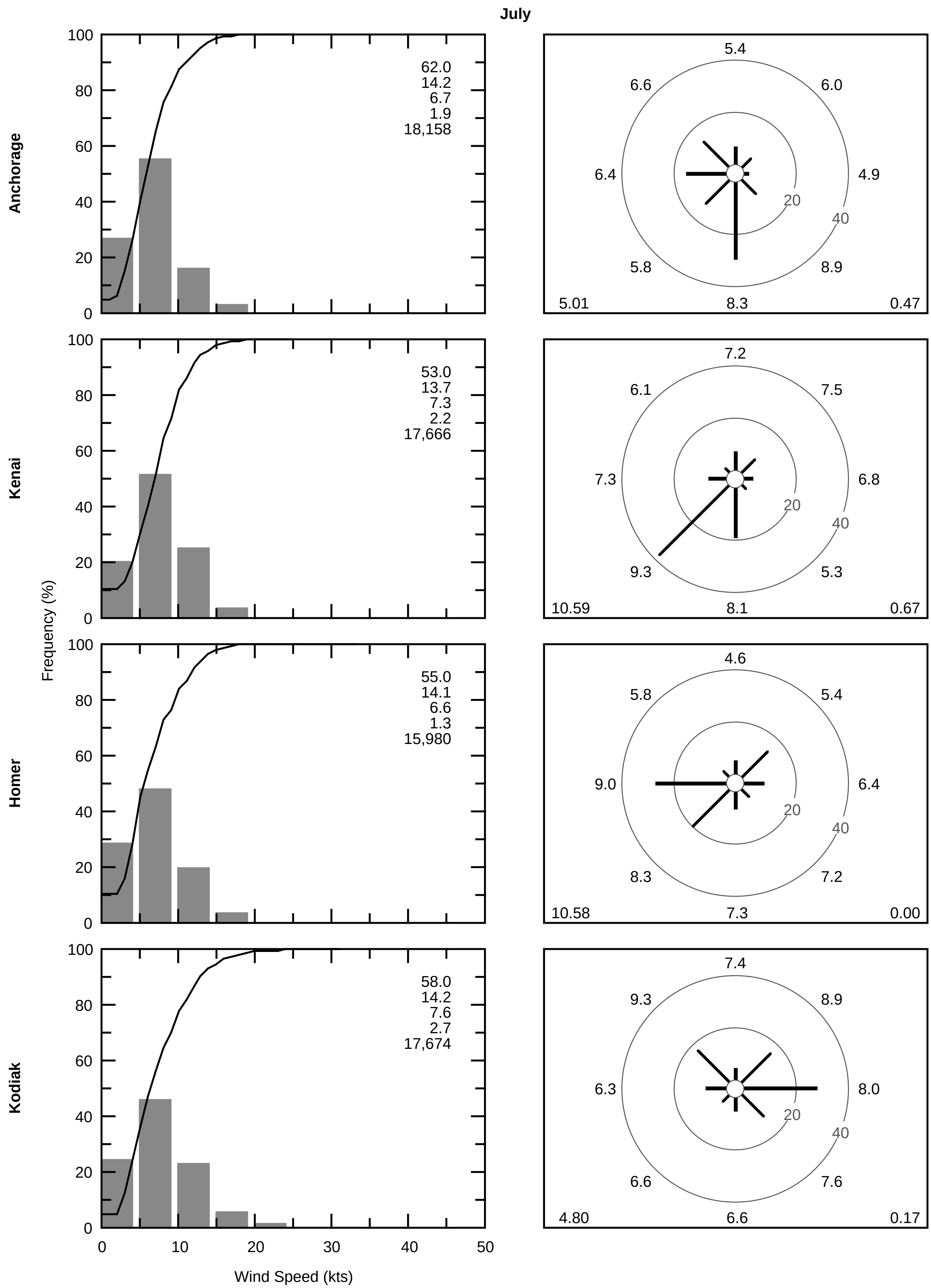

Anchorage
56.0
13.9
6.5
1.7
17,634
7.0
6.5
6.6
5.8
5.1
20
40
5.2
8.8
5.97
8.3
0.48
Kenai
55.0
15.7
7.5
2.2
17,229
9.0
6.8
9.7
7.2
7.8
20
40
8.3
6.3
13.08
7.6
0.52
Homer
55.0
16.2
7.4
1.9
15,848
6.3
6.3
7.4
8.9
9.0
20
40
8.9
8.7
8.13
8.0
0.00
Kodiak
55.0
21.4
10.7
4.7
17,256
10.2
11.8
12.7
8.2
12.1
20
40
7.6
11.1
2.01
7.8
0.01
Frequency (%)
0
20
40
60
80
100
0
10
20
30
40
50
Wind Speed (kts)

May

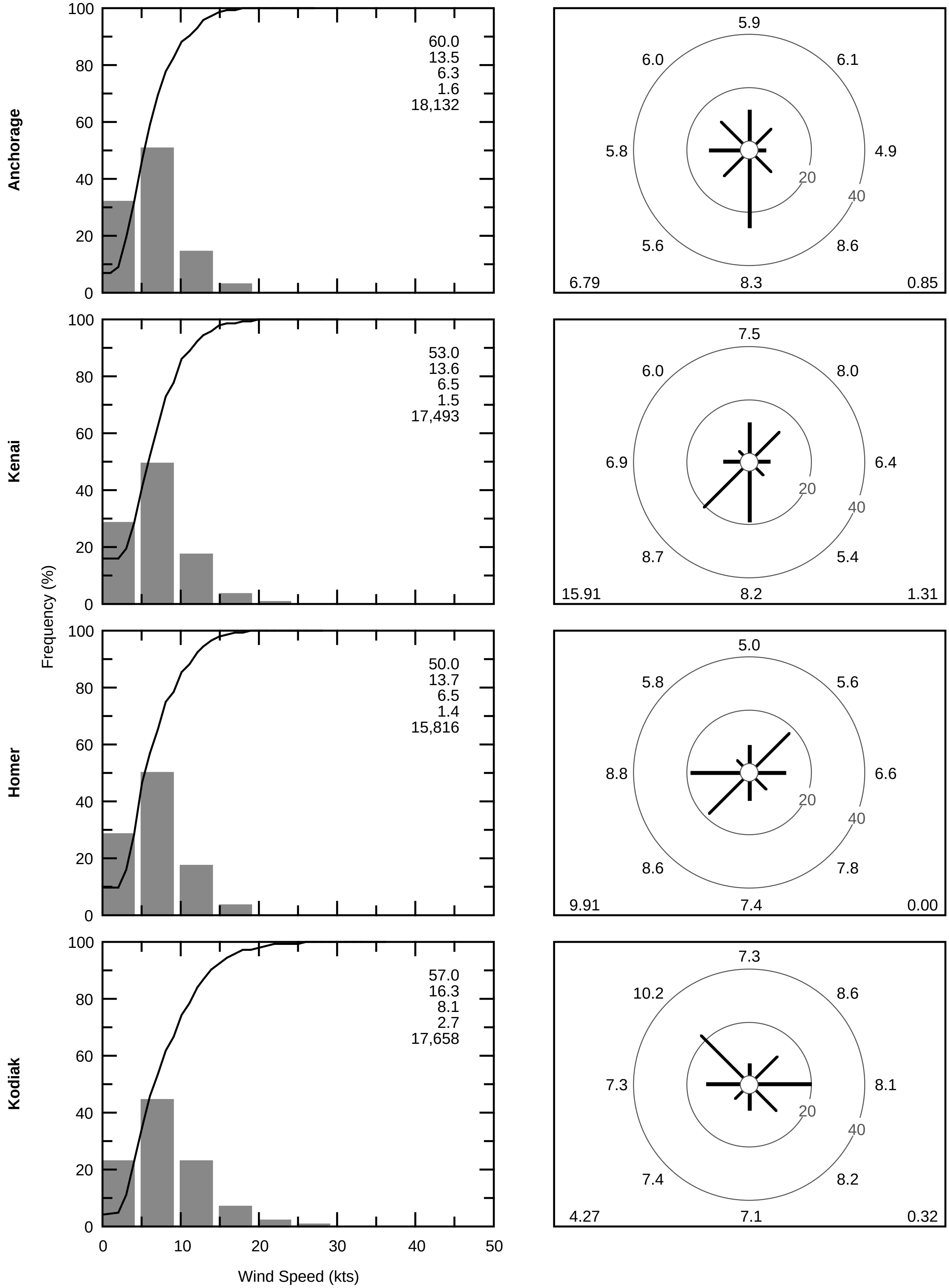

Anchorage
37.0
16.6
7.5
2.0
18,230
5.9
6.8
6.0
6.7
5.4
6.3
9.7
9.3
4.15
0.43
Kenai
58.0
15.3
7.6
2.0
17,772
8.7
7.4
9.1
8.2
8.1
9.4
6.3
8.2
10.91
0.53
Homer
45.0
16.3
7.6
1.7
16,475
5.3
5.4
6.6
9.4
9.0
9.0
8.6
8.4
8.01
0.00
Kodiak
57.0
19.1
10.0
4.4
17,609
9.3
10.1
11.9
8.1
11.5
8.1
10.0
8.0
1.89
0.10
20
40
Frequency (%)
Wind Speed (kts)

June

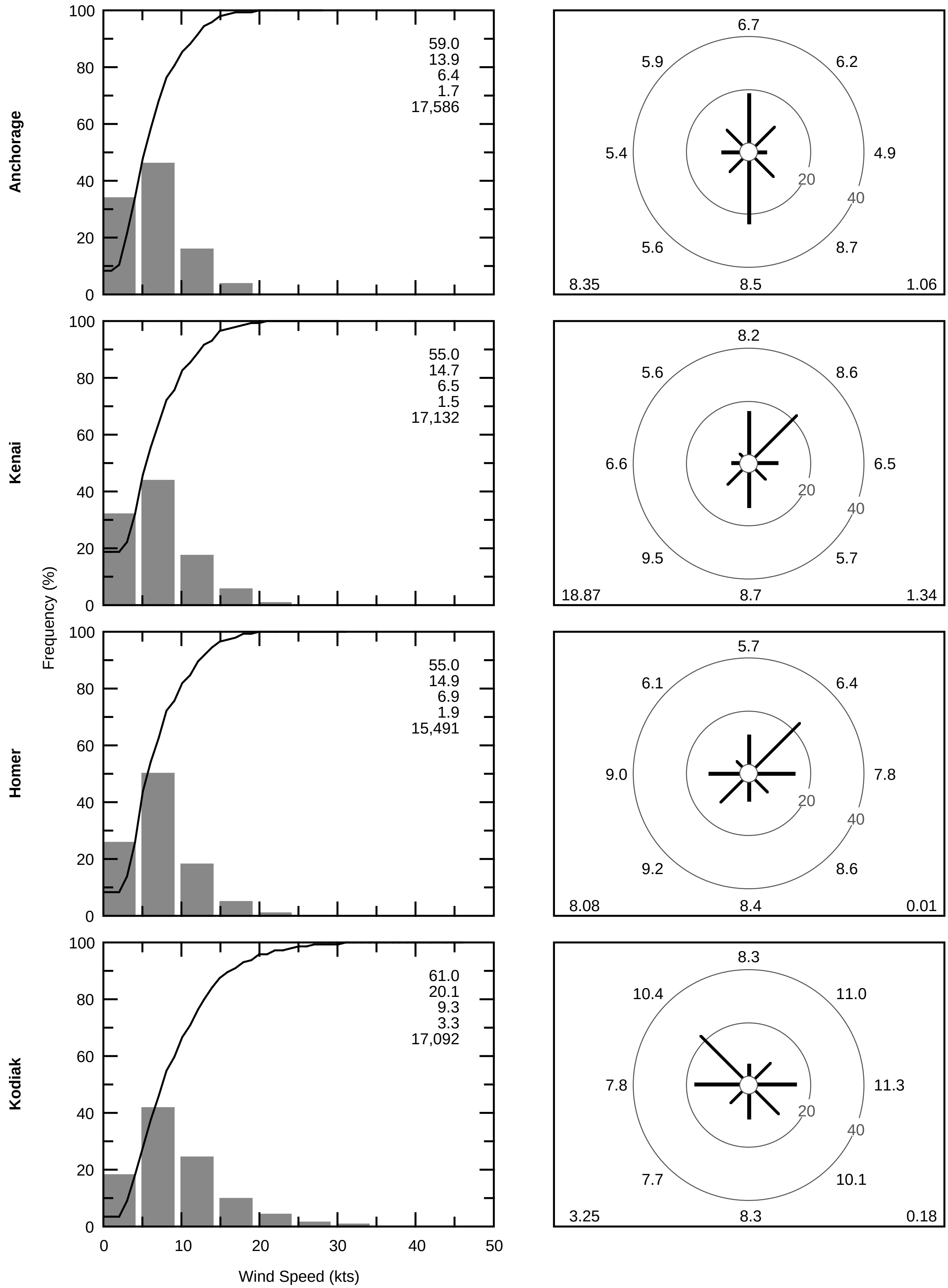

Anchorage
Kenai
Homer
Kodiak
Frequency (%)
Wind Speed (kts)
0
10
20
30
40
50
100
80
60
40
20
0
54.0
16.3
7.6
2.2
17,564
5.7
6.9
5.9
6.8
4.9
20
40
6.2
9.8
3.85
9.3
0.22
55.0
15.1
7.9
2.3
17,165
7.8
6.9
8.4
7.9
7.6
9.8
6.4
8.89
8.6
0.33
55.0
15.7
7.5
1.4
16,141
4.7
5.5
6.0
9.5
8.0
8.9
8.5
8.04
8.2
0.00
57.0
16.4
8.9
3.7
17,024
9.2
9.5
10.7
6.4
9.9
7.4
8.8
3.30
7.2
0.14


July
Anchorage
62.0
14.2
6.7
1.9
18,158
5.4
6.6
6.0
6.4
4.9
20
40
5.8
8.9
5.01
8.3
0.47
Kenai
53.0
13.7
7.3
2.2
17,666
7.2
6.1
7.5
7.3
6.8
20
40
9.3
5.3
10.59
8.1
0.67
Homer
55.0
14.1
6.6
1.3
15,980
4.6
5.8
5.4
9.0
6.4
20
40
8.3
7.2
10.58
7.3
0.00
Kodiak
58.0
14.2
7.6
2.7
17,674
7.4
9.3
8.9
6.3
8.0
20
40
6.6
7.6
4.80
6.6
0.17
Frequency (%)
0
20
40
60
80
100
0
10
20
30
40
50
Wind Speed (kts)

August

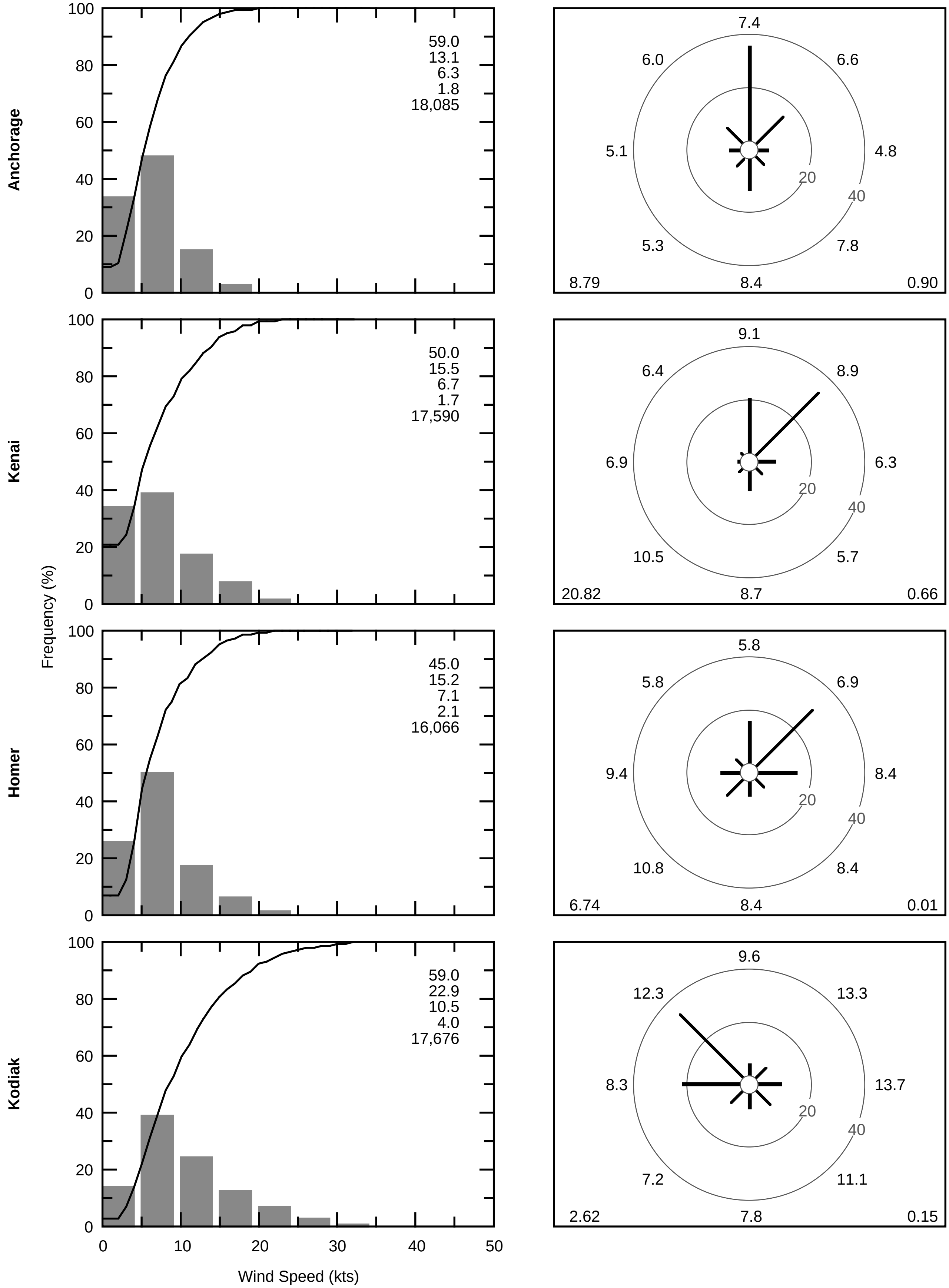

Anchorage
60.0
13.5
6.3
1.6
18,132
5.9
6.0
6.1
5.8
4.9
20
40
5.6
8.6
6.79
8.3
0.85
Kenai
53.0
13.6
6.5
1.5
17,493
7.5
6.0
8.0
6.9
6.4
8.7
5.4
15.91
8.2
1.31
Homer
50.0
13.7
6.5
1.4
15,816
5.0
5.8
5.6
8.8
6.6
8.6
7.8
9.91
7.4
0.00
Kodiak
57.0
16.3
8.1
2.7
17,658
7.3
10.2
8.6
7.3
8.1
7.4
8.2
4.27
7.1
0.32
Frequency (%)
Wind Speed (kts)
0
10
20
30
40
50
100
80
60

September

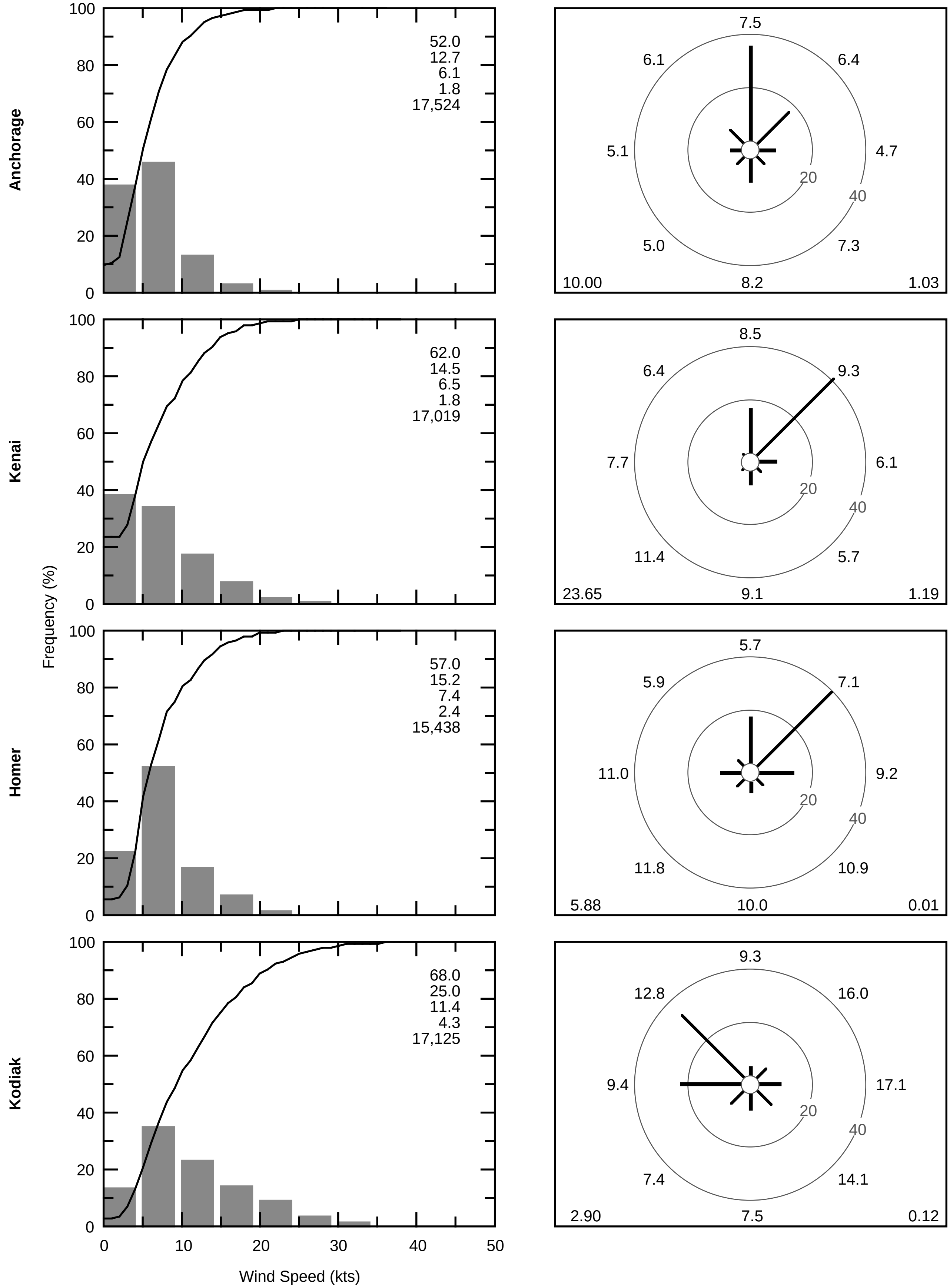


Anchorage
59.0
13.9
6.4
1.7
17,586
6.7
5.9
6.2
5.4
4.9
5.6
8.7
8.35
8.5
1.06
Kenai
55.0
14.7
6.5
1.5
17,132
8.2
5.6
8.6
6.6
6.5
9.5
5.7
18.87
8.7
1.34
Homer
55.0
14.9
6.9
1.9
15,491
5.7
6.1
6.4
9.0
7.8
9.2
8.6
8.08
8.4
0.01
Kodiak
61.0
20.1
9.3
3.3
17,092
8.3
10.4
11.0
7.8
11.3
7.7
10.1
3.25
8.3
0.18
20
40
Frequency (%)
0
20
40
60
80
100
0
10
20
30
40
50
Wind Speed (kts)

October

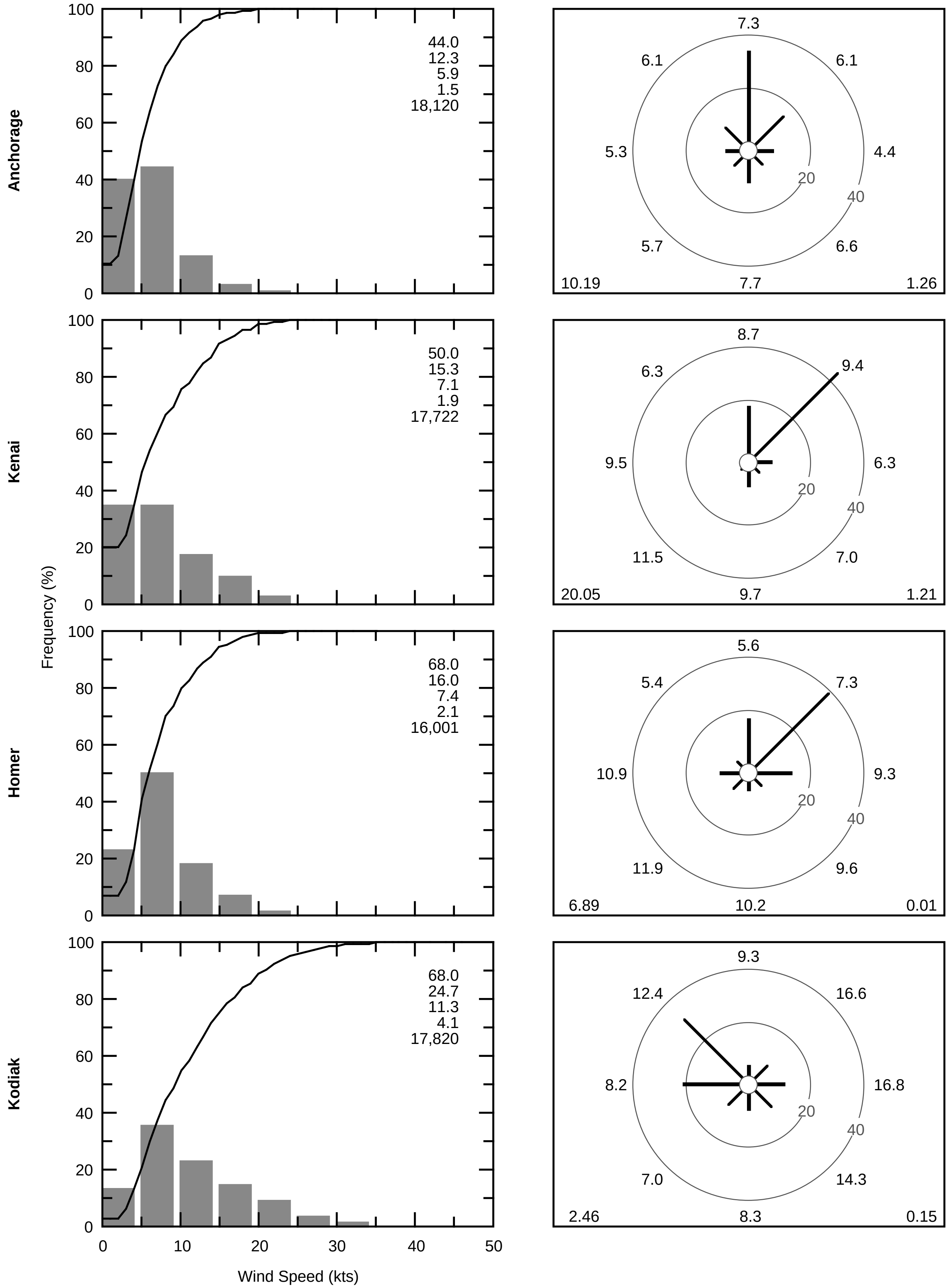

Anchorage
Kenai
Homer
Kodiak
Frequency (%)
Wind Speed (kts)
100
80
60
40
20
0
0
10
20
30
40
50
59.0
13.1
6.3
1.8
18,085
7.4
6.0
6.6
5.1
4.8
5.3
7.8
8.79
8.4
0.90
50.0
15.5
6.7
1.7
17,590
9.1
6.4
8.9
6.9
6.3
10.5
5.7
20.82
8.7
0.66
45.0
15.2
7.1
2.1
16,066
5.8
5.8
6.9
9.4
8.4
10.8
8.4
6.74
8.4
0.01
59.0
22.9
10.5
4.0
17,676
9.6
12.3
13.3
8.3
13.7
7.2
11.1
2.62
7.8
0.15
20
40

November



Anchorage
Kenai
Homer
Kodiak
Frequency (%)
Wind Speed (kts)
0
10
20
30
40
50
100
80
60
40
20
0
52.0
12.7
6.1
1.8
17,524
7.5
6.1
6.4
5.1
4.7
5.0
7.3
8.2
10.00
1.03
62.0
14.5
6.5
1.8
17,019
8.5
6.4
9.3
7.7
6.1
11.4
5.7
9.1
23.65
1.19
57.0
15.2
7.4
2.4
15,438
5.7
5.9
7.1
11.0
9.2
11.8
10.9
10.0
5.88
0.01
68.0
25.0
11.4
4.3
17,125
9.3
12.8
16.0
9.4
17.1
7.4
14.1
7.5
2.90
0.12
20
40

December


Anchorage
44.0
12.3
5.9
1.5
18,120
7.3
6.1
6.1
5.3
4.4
20
40
5.7
6.6
10.19
7.7
1.26
Kenai
50.0
15.3
7.1
1.9
17,722
8.7
6.3
9.4
9.5
6.3
20
40
11.5
7.0
20.05
9.7
1.21
Homer
68.0
16.0
7.4
2.1
16,001
5.6
5.4
7.3
10.9
9.3
20
40
11.9
9.6
6.89
10.2
0.01
Kodiak
68.0
24.7
11.3
4.1
17,820
9.3
12.4
16.6
8.2
16.8
20
40
7.0
14.3
2.46
8.3
0.15
Frequency (%)
0
20
40
60
80
100
0
10
20
30
40
50
Wind Speed (kts)

APPENDIX F: WIND CHILL

Wind chill is a term that is used to describe the rate of heat loss from exposed skin caused by the combined effects of wind and temperature. If there is no wind, heat emanating from an object will remain near the object and warm the air around it, thus providing a measure of insulation that inhibits further cooling. Air movement, though, will conduct heat away from the warm object, a process known as advection. As the wind speed increases, heat is advected away more quickly, resulting in more rapid cooling of the object. The wind chill temperature is a calculated temperature that provides a better indication of the cooling capacity of the wind in conjunction with low temperatures. It was originally based on the length of time required for a container of near-freezing water to become frozen under various combinations of wind and temperature. The wind-chill temperature is equal to the dry bulb temperature that is required to cool the object at the same rate as if there were no ambient air movement.

The concept was first quantified in 1941 by Paul Siple, an Army major and geographer, and Charles Passel, a geologist, while stationed at Little America, Antarctica. Their experiments were based on the time required to freeze a known volume of water under various combinations of temperature and wind speed during the winter darkness of Antarctic. Since the publication of their results (Siple and Passel 1945), the concept of an equivalent wind chill temperature has enjoyed widespread use as a means of describing the combined severity of the wind and low temperatures on human beings. In the years since, several individuals have suggested improvements to the Siple and Passel model. Their criticism stems from the fact that cylinders of water are not lifelike because they have no metabolic heat source as does the human body and were not clothed as a human would be. As such, cylinders of water will freeze faster than flesh, so the original heat-loss relationship underestimates the time of freezing and accordingly overestimates the chilling effect of the wind.

The model in current use by the National Weather Service (Quayle and Steadman 1998) is

$$WC = 0.0817\,(3.71\,V^{0.5} + 5.81 - 0.25\,V)\,(T - 91.4) + 91.4 \qquad \text{(F1)}$$

where WC = equivalent wind-chill temperature
V = wind speed (statute mph)
T = temperature (°F)

or

$$WC = 0.045(5.27\,V^{0.5} + 10.45 - 0.28\,V)\,(T - 33) + 33 \qquad \text{(F2)}$$

where WC = wind-chill temperature
V = wind speed (km/h)
T = temperature (°C).

These formulas are only valid for wind speeds ranging from 4 to 40 mph (6.4 to 64 km/hr). Increasing wind speed will not cause an exposed object to be colder than ambient temperature. The object will achieve a temperature equal to ambient, and higher wind speeds will only cause the ambient temperature to be achieved more quickly. Table F1 shows equivalent wind chill temperatures in both English and metric units.

Table F1. Equivalent wind chill temperature.

Wind Speed		Temperature (°F)																
Calm		35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
mi/hr	knots	Equivalent Wind Chill Temperature (°F)																
4	5	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	6	32	27	22	16	11	6	1	-5	-10	-15	-20	-26	-31	-36	-41	-47	-52
10	12	22	16	10	4	-2	-9	-15	-21	-27	-33	-39	-46	-52	-58	-64	-70	-76
15	17	16	9	2	-4	-11	-18	-25	-31	-38	-45	-51	-58	-65	-72	-78	-85	-92
20	23	11	4	-3	-10	-17	-24	-31	-39	-46	-53	-60	-67	-74	-81	-88	-95	-103
25	29	8	1	-7	-14	-22	-29	-36	-44	-51	-59	-66	-73	-81	-88	-96	-103	-110
30	35	6	-2	-10	-17	-25	-32	-40	-48	-55	-63	-71	-78	-86	-93	-101	-109	-116
35	40	4	-4	-12	-19	-27	-35	-43	-51	-58	-66	-74	-82	-89	-97	-105	-113	-120
40	46	3	-5	-13	-21	-29	-37	-45	-53	-60	-68	-76	-84	-92	-100	-108	-116	-123
45	52	2	-6	-14	-22	-30	-38	-46	-54	-62	-70	-78	-86	-94	-101	-109	-117	-125

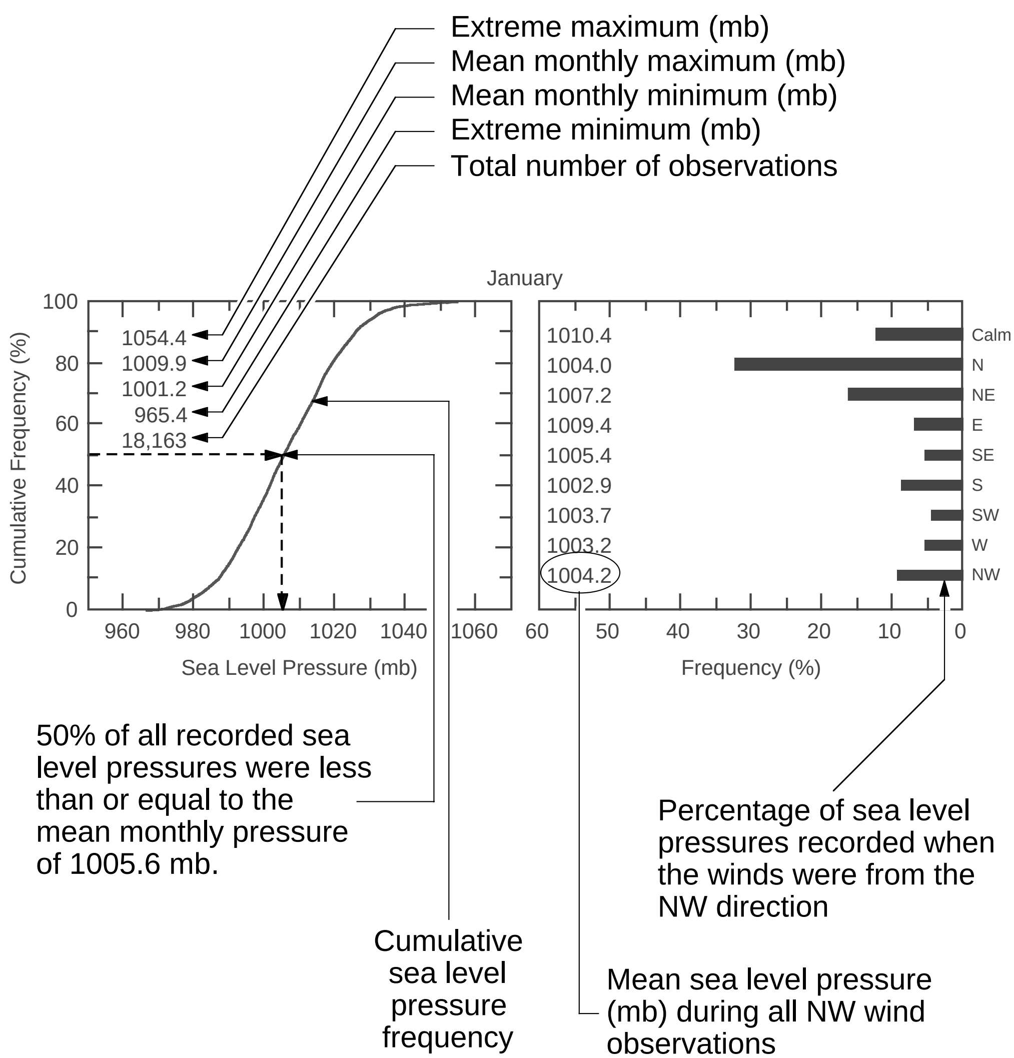
Wind Speed		Temperature (°C)																
Calm		2	-1	-4	-7	-9	-12	-15	-18	-21	-23	-26	-29	-32	-34	-37	-40	-43
m/s	km/hr	Equivalent Wind Chill Temperature (°C)																
9	6	2	0	-3	-6	-8	-11	-14	-17	-19	-22	-25	-27	-30	-33	-36	-38	-41
11	8	0	-3	-5	-8	-11	-14	-17	-20	-23	-26	-29	-31	-34	-37	-40	-43	-46
22	16	-5	-9	-12	-15	-19	-22	-26	-29	-32	-36	-39	-42	-46	-49	-53	-56	-59
34	24	-9	-12	-16	-20	-24	-27	-31	-35	-38	-42	-46	-49	-53	-57	-60	-64	-68
45	32	-11	-15	-19	-23	-27	-31	-35	-39	-43	-46	-50	-54	-58	-62	-66	-70	-74
56	40	-13	-17	-21	-25	-29	-33	-37	-42	-46	-50	-54	-58	-62	-66	-70	-74	-78
67	48	-14	-18	-23	-27	-31	-35	-39	-44	-48	-52	-56	-60	-65	-69	-73	-77	-81
78	56	-15	-20	-24	-28	-32	-37	-41	-45	-49	-54	-58	-62	-67	-71	-75	-79	-84
89	64	-16	-20	-25	-29	-33	-38	-42	-46	-51	-55	-59	-64	-68	-72	-77	-81	-85
101	72	-16	-21	-25	-30	-34	-38	-43	-47	-51	-56	-60	-65	-69	-73	-78	-82	-86

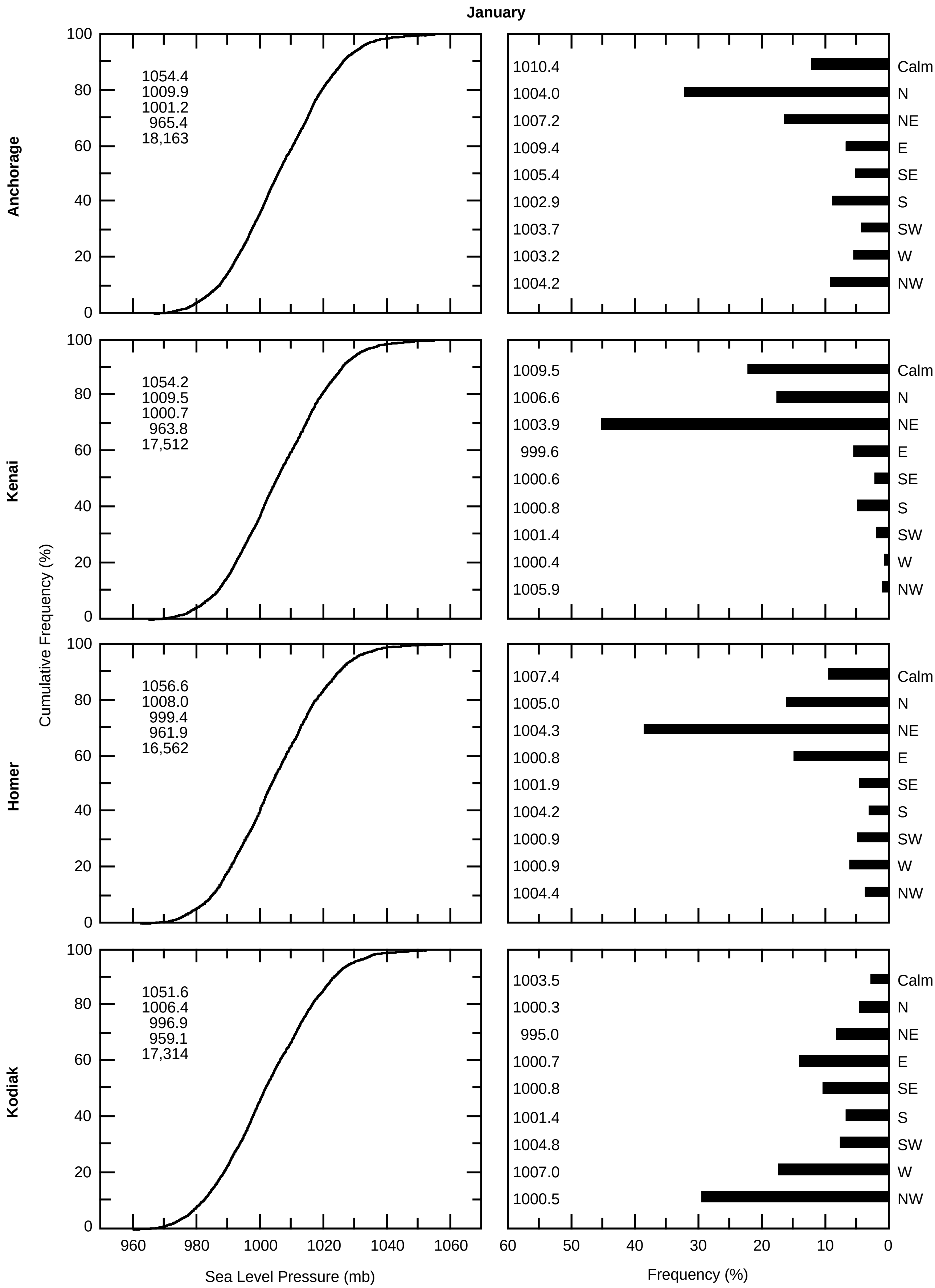
Comfort Scale Legend	Cold	Very Cold	Bitter Cold	Extreme Cold

Notes:
The wind chill formula is not valid for wind speeds of 4 mph and less.
Wind speeds greater than 40 mph have little additional cooling effect.
Due to rounding, values may vary slightly from those shown in other wind chill charts.
Source: National Weather Service.

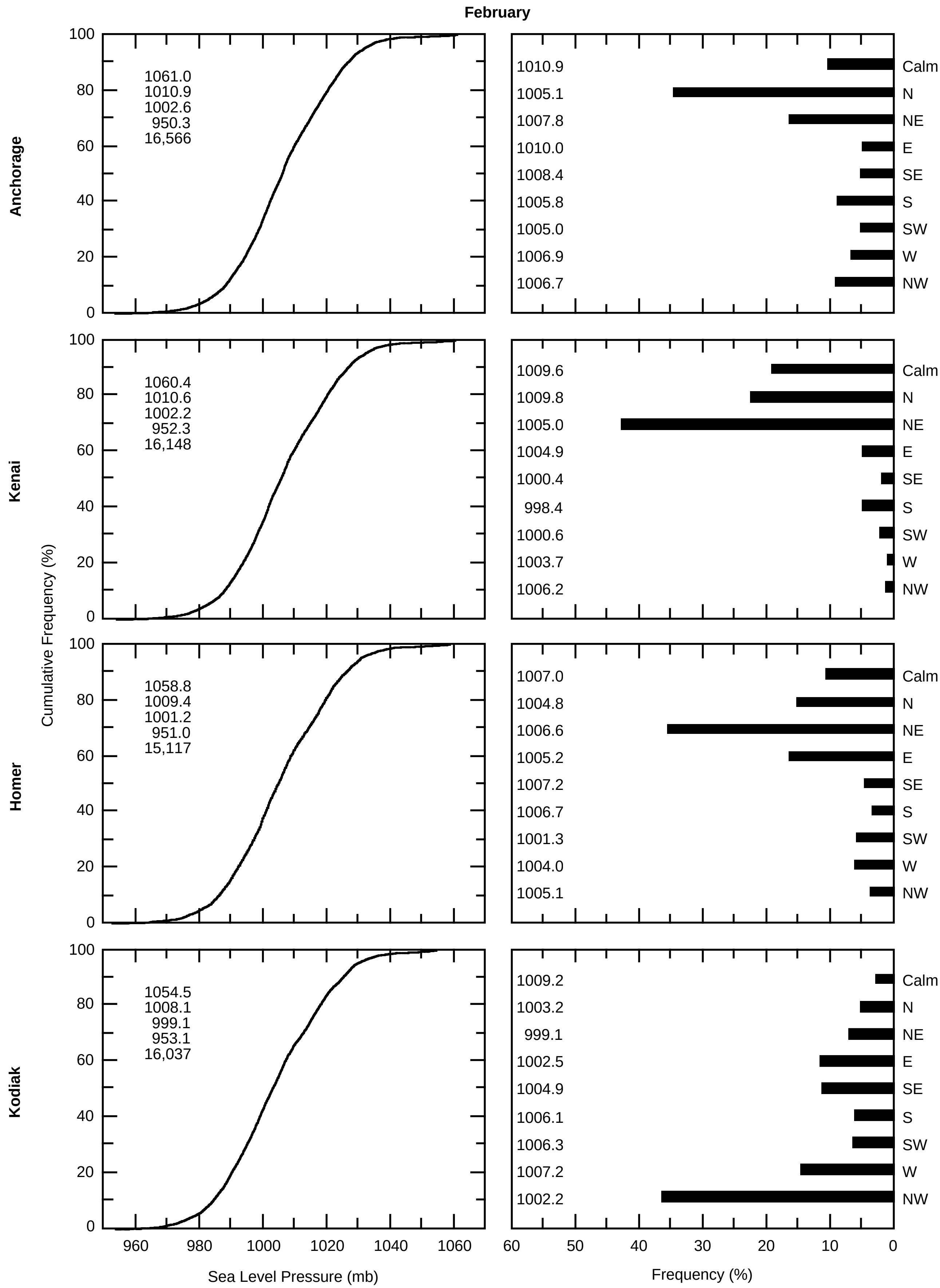
APPENDIX G: SEA LEVEL PRESSURE

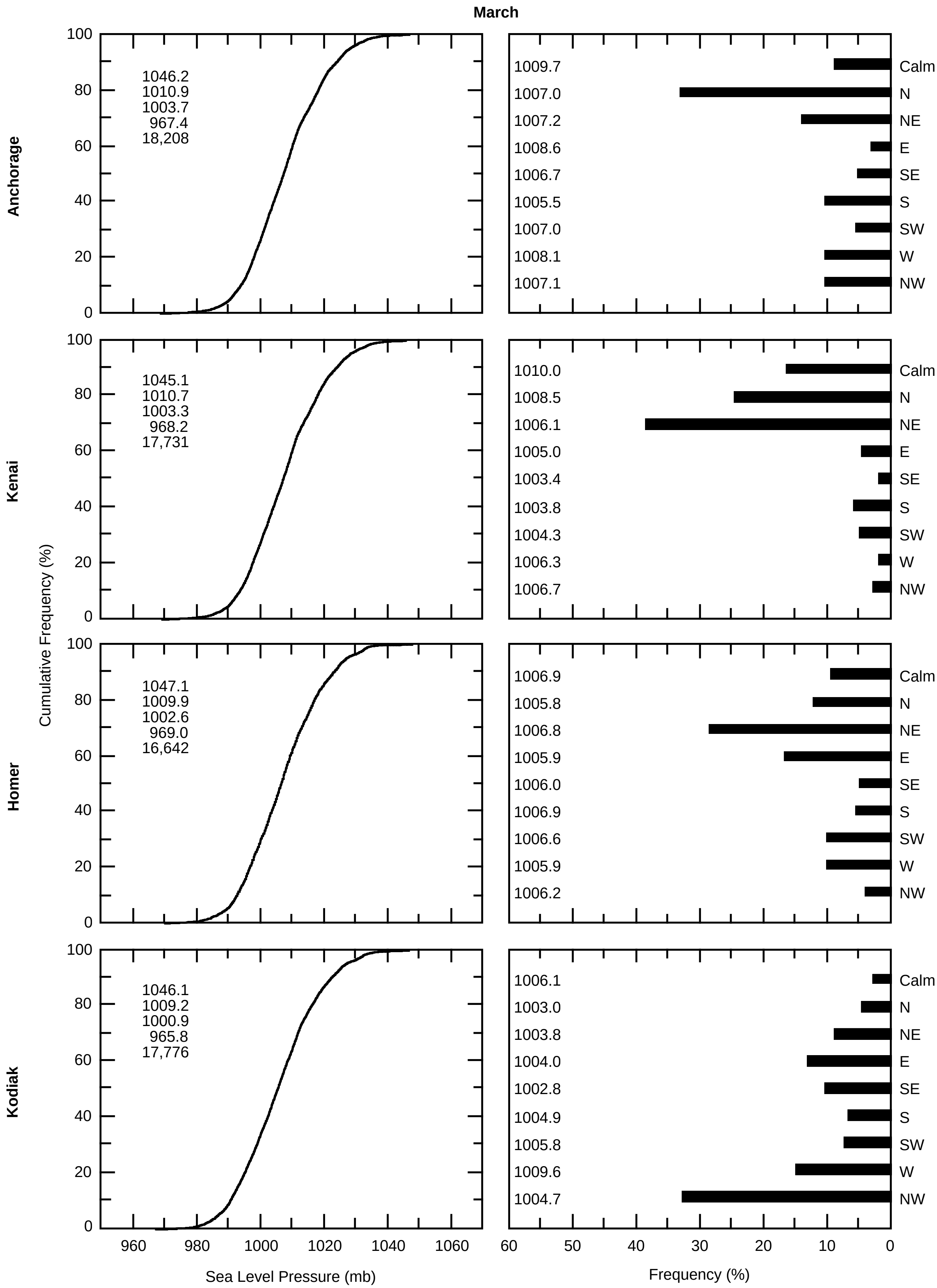
Sea level pressure statistics for Anchorage, Kenai, Homer, and Kodiak, Alaska, are presented. The data were assembled and summarized specifically for this project by the Air Force Combat Climatology Center as described in Section 6.1 (Source and Description of Climatological Data for Cook Inlet) from hourly observations of the sea level pressure for Jan. 1973–Dec. 1997 (except Jan. 1973–Oct. 1997 for Homer). The graphs on the left of the page represent cumulative percent frequency distribution curves for each month of the year. The values listed in the upper left corner of each graph are the extreme maximum and minimum pressures, the mean monthly maximum and minimum pressures, and the total number of observations for the period of record. The second graph (in bar-chart form) shows the frequency distribution of sea level pressure observations and the mean pressure associated with winds from each compass direction and for calm winds.

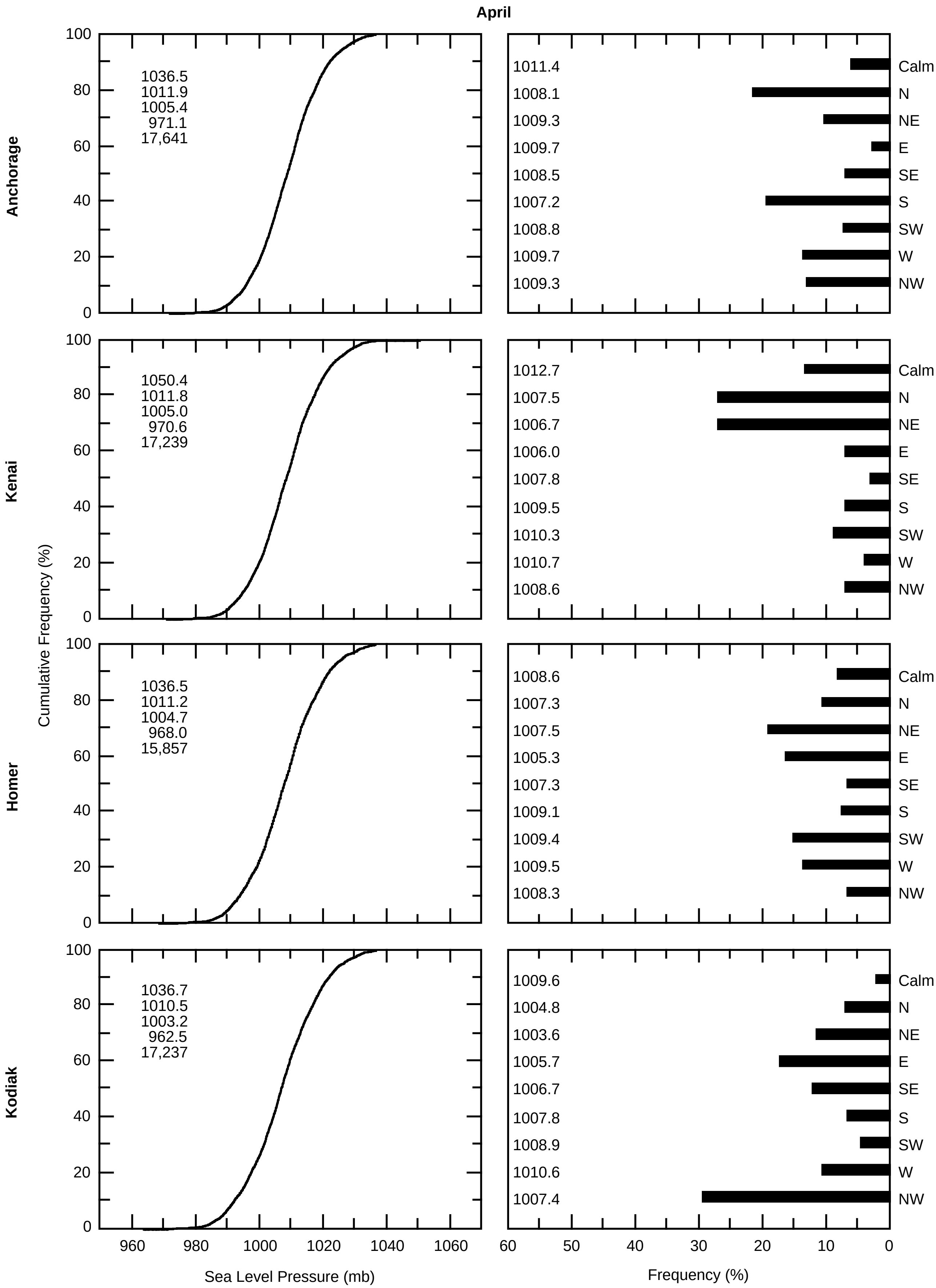




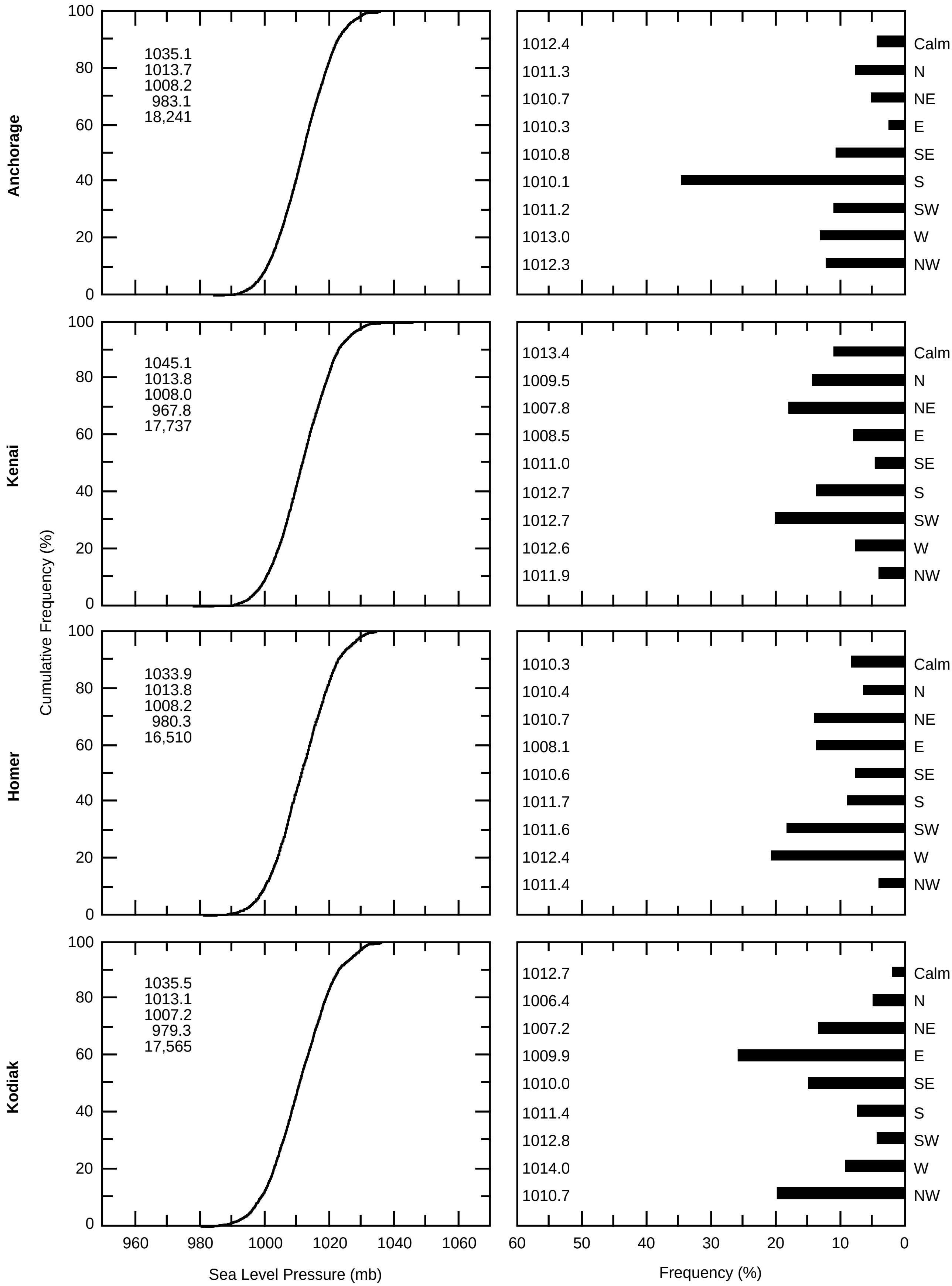
January
Anchorage
1054.4
1009.9
1001.2
965.4
18,163
1010.4 Calm
1004.0 N
1007.2 NE
1009.4 E
1005.4 SE
1002.9 S
1003.7 SW
1003.2 W
1004.2 NW
Kenai
1054.2
1009.5
1000.7
963.8
17,512
1009.5 Calm
1006.6 N
1003.9 NE
999.6 E
1000.6 SE
1000.8 S
1001.4 SW
1000.4 W
1005.9 NW
Homer
1056.6
1008.0
999.4
961.9
16,562
1007.4 Calm
1005.0 N
1004.3 NE
1000.8 E
1001.9 SE
1004.2 S
1000.9 SW
1000.9 W
1004.4 NW
Kodiak
1051.6
1006.4
996.9
959.1
17,314
1003.5 Calm
1000.3 N
995.0 NE
1000.7 E
1000.8 SE
1001.4 S
1004.8 SW
1007.0 W
1000.5 NW
Cumulative Frequency (%)
0
20
40
60
80
100
960
980
1000
1020
1040
1060
Sea Level Pressure (mb)
60
50
40
30
20
10
0
Frequency (%)

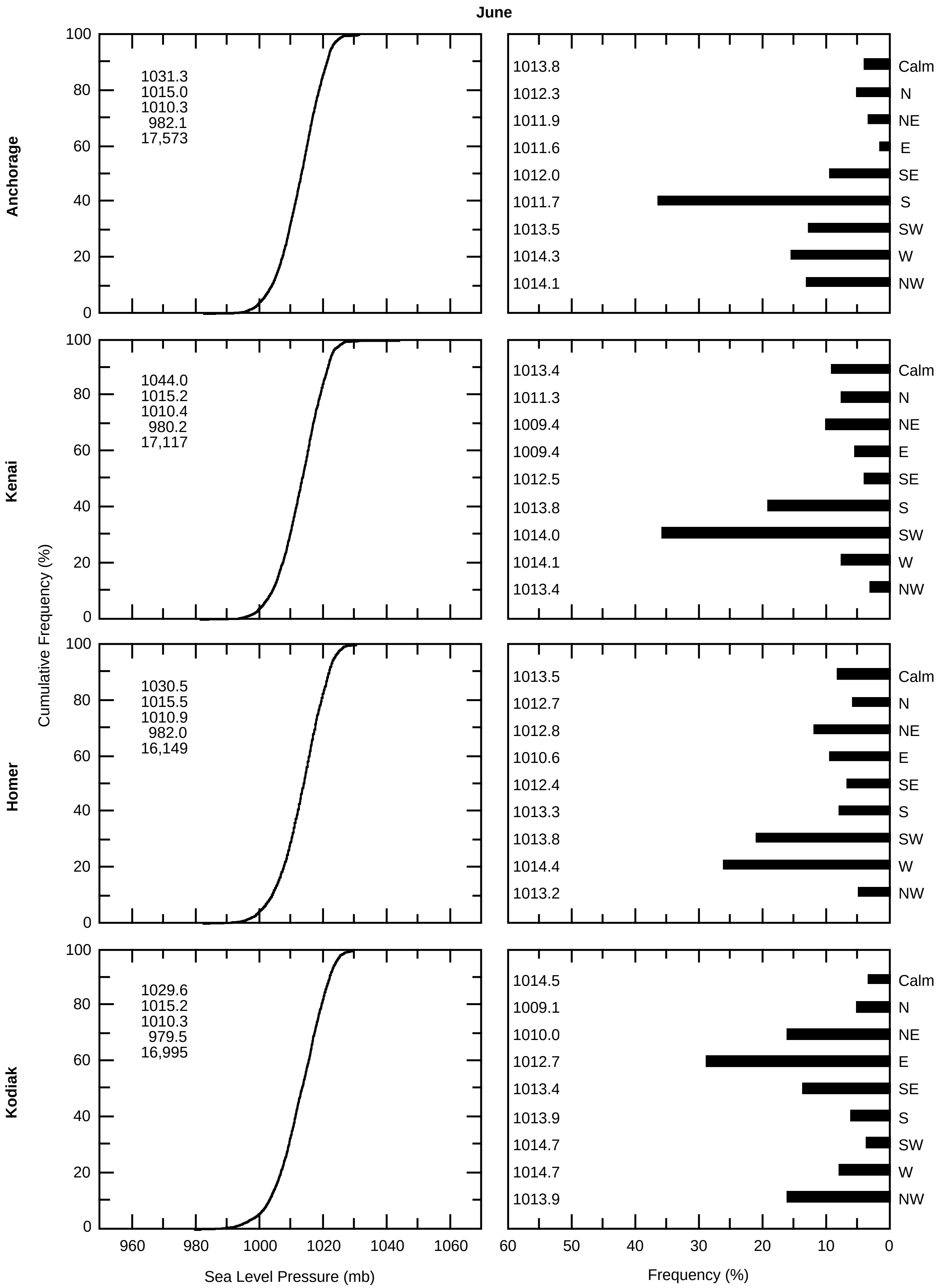

February
Anchorage
1061.0
1010.9
1002.6
950.3
16,566
1010.9 Calm
1005.1 N
1007.8 NE
1010.0 E
1008.4 SE
1005.8 S
1005.0 SW
1006.9 W
1006.7 NW
Kenai
1060.4
1010.6
1002.2
952.3
16,148
1009.6 Calm
1009.8 N
1005.0 NE
1004.9 E
1000.4 SE
998.4 S
1000.6 SW
1003.7 W
1006.2 NW
Homer
1058.8
1009.4
1001.2
951.0
15,117
1007.0 Calm
1004.8 N
1006.6 NE
1005.2 E
1007.2 SE
1006.7 S
1001.3 SW
1004.0 W
1005.1 NW
Kodiak
1054.5
1008.1
999.1
953.1
16,037
1009.2 Calm
1003.2 N
999.1 NE
1002.5 E
1004.9 SE
1006.1 S
1006.3 SW
1007.2 W
1002.2 NW
Cumulative Frequency (%)
0
20
40
60
80
100
960
980
1000
1020
1040
1060
Sea Level Pressure (mb)
60
50
40
30
20
10
0
Frequency (%)


March
Anchorage
1046.2
1010.9
1003.7
967.4
18,208
1009.7 Calm
1007.0 N
1007.2 NE
1008.6 E
1006.7 SE
1005.5 S
1007.0 SW
1008.1 W
1007.1 NW
Kenai
1045.1
1010.7
1003.3
968.2
17,731
1010.0 Calm
1008.5 N
1006.1 NE
1005.0 E
1003.4 SE
1003.8 S
1004.3 SW
1006.3 W
1006.7 NW
Homer
1047.1
1009.9
1002.6
969.0
16,642
1006.9 Calm
1005.8 N
1006.8 NE
1005.9 E
1006.0 SE
1006.9 S
1006.6 SW
1005.9 W
1006.2 NW
Kodiak
1046.1
1009.2
1000.9
965.8
17,776
1006.1 Calm
1003.0 N
1003.8 NE
1004.0 E
1002.8 SE
1004.9 S
1005.8 SW
1009.6 W
1004.7 NW
Cumulative Frequency (%)
0
20
40
60
80
100
960
980
1000
1020
1040
1060
Sea Level Pressure (mb)
60
50
40
30
20
10
0
Frequency (%)

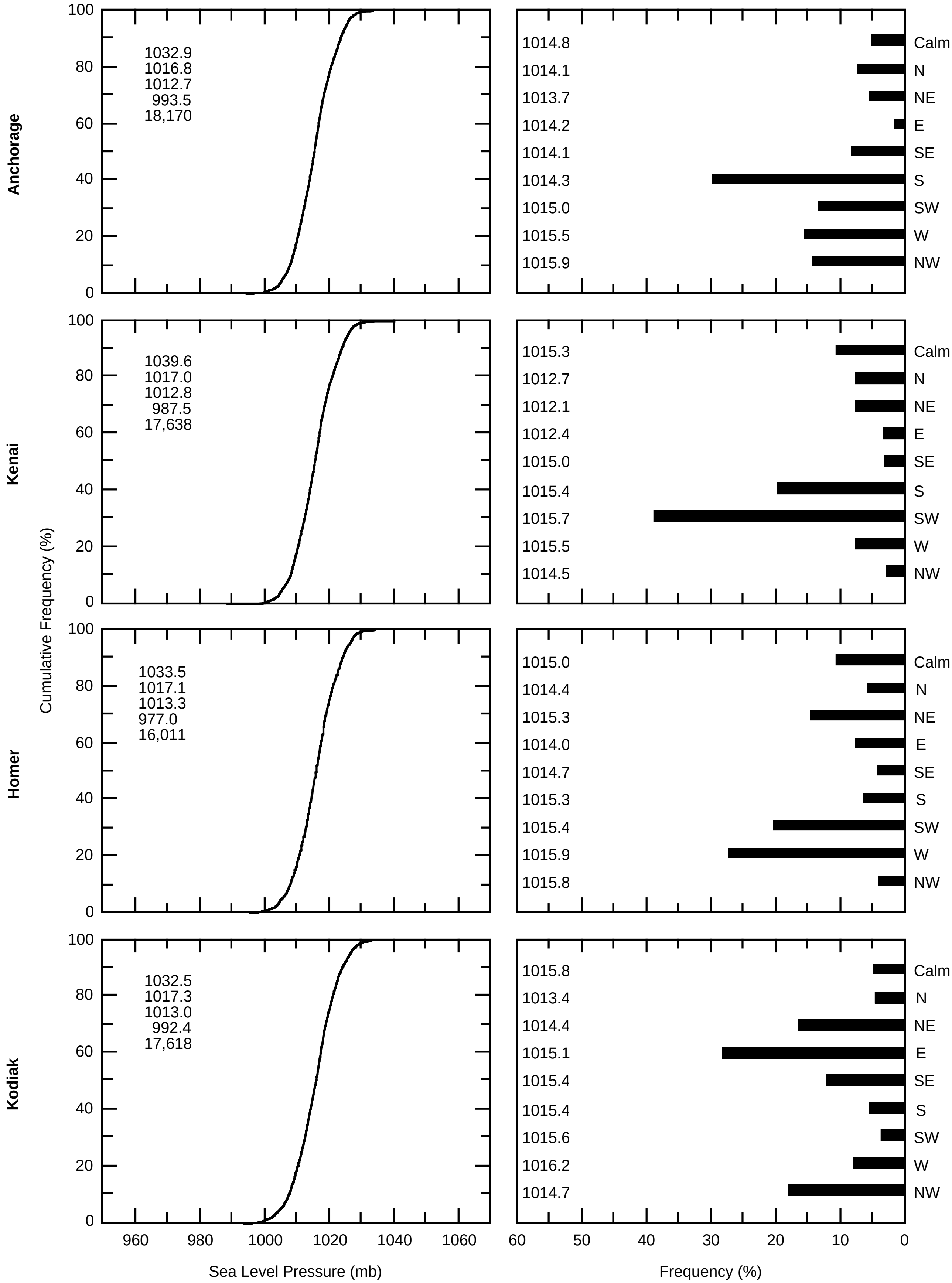

April
Anchorage
1036.5
1011.9
1005.4
971.1
17,641
1011.4 Calm
1008.1 N
1009.3 NE
1009.7 E
1008.5 SE
1007.2 S
1008.8 SW
1009.7 W
1009.3 NW
Kenai
1050.4
1011.8
1005.0
970.6
17,239
1012.7 Calm
1007.5 N
1006.7 NE
1006.0 E
1007.8 SE
1009.5 S
1010.3 SW
1010.7 W
1008.6 NW
Homer
1036.5
1011.2
1004.7
968.0
15,857
1008.6 Calm
1007.3 N
1007.5 NE
1005.3 E
1007.3 SE
1009.1 S
1009.4 SW
1009.5 W
1008.3 NW
Kodiak
1036.7
1010.5
1003.2
962.5
17,237
1009.6 Calm
1004.8 N
1003.6 NE
1005.7 E
1006.7 SE
1007.8 S
1008.9 SW
1010.6 W
1007.4 NW
Cumulative Frequency (%)
Sea Level Pressure (mb)
Frequency (%)

May

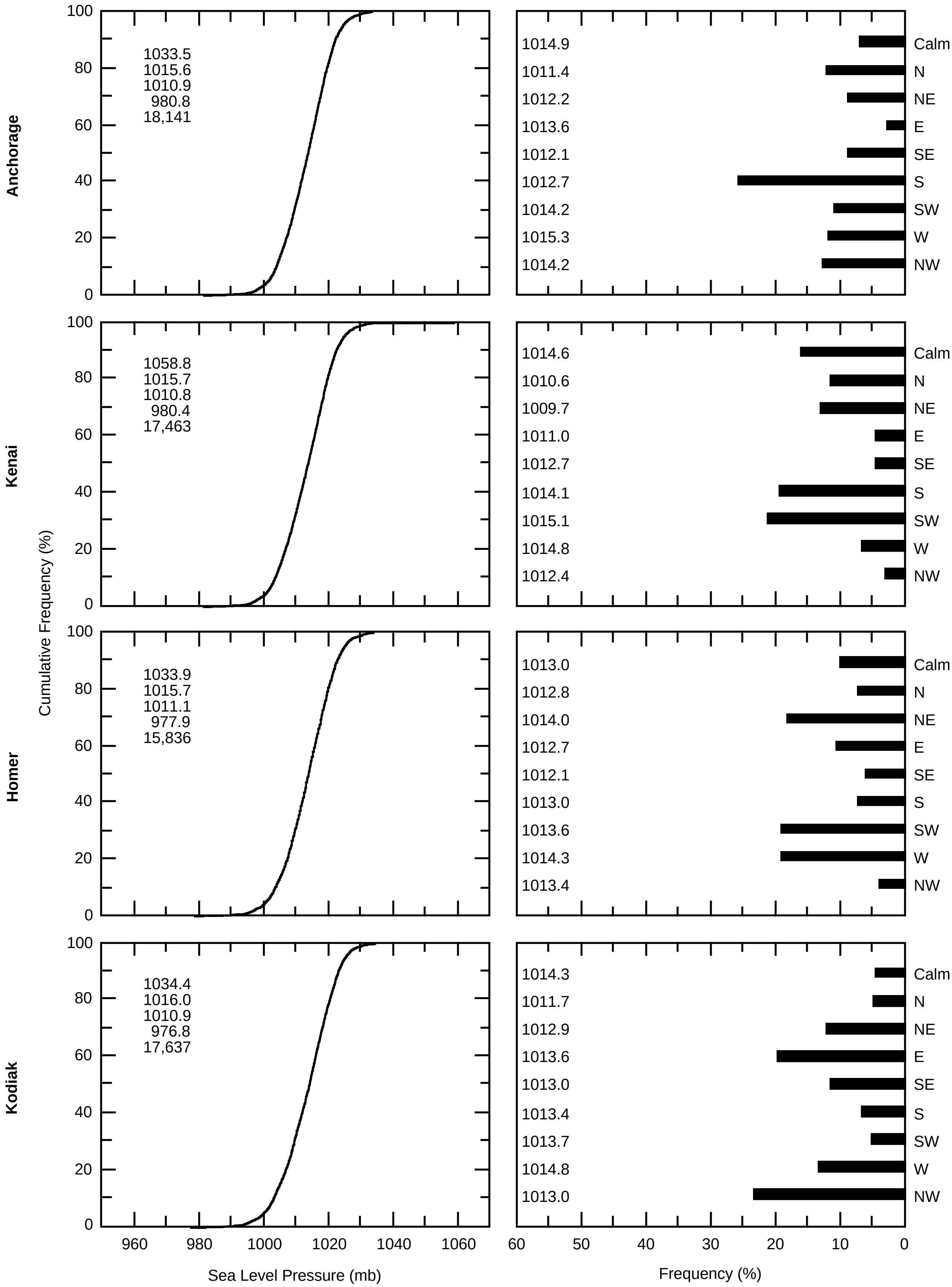

Anchorage
1035.1
1013.7
1008.2
983.1
18,241
1012.4 Calm
1011.3 N
1010.7 NE
1010.3 E
1010.8 SE
1010.1 S
1011.2 SW
1013.0 W
1012.3 NW
Kenai
1045.1
1013.8
1008.0
967.8
17,737
1013.4 Calm
1009.5 N
1007.8 NE
1008.5 E
1011.0 SE
1012.7 S
1012.7 SW
1012.6 W
1011.9 NW
Homer
1033.9
1013.8
1008.2
980.3
16,510
1010.3 Calm
1010.4 N
1010.7 NE
1008.1 E
1010.6 SE
1011.7 S
1011.6 SW
1012.4 W
1011.4 NW
Kodiak
1035.5
1013.1
1007.2
979.3
17,565
1012.7 Calm
1006.4 N
1007.2 NE
1009.9 E
1010.0 SE
1011.4 S
1012.8 SW
1014.0 W
1010.7 NW
Cumulative Frequency (%)
0 20 40 60 80 100
960 980 1000 1020 1040 1060
Sea Level Pressure (mb)
60 50 40 30 20 10 0
Frequency (%)


June
Anchorage
1031.3
1015.0
1010.3
982.1
17,573
1013.8 Calm
1012.3 N
1011.9 NE
1011.6 E
1012.0 SE
1011.7 S
1013.5 SW
1014.3 W
1014.1 NW
Kenai
1044.0
1015.2
1010.4
980.2
17,117
1013.4 Calm
1011.3 N
1009.4 NE
1009.4 E
1012.5 SE
1013.8 S
1014.0 SW
1014.1 W
1013.4 NW
Homer
1030.5
1015.5
1010.9
982.0
16,149
1013.5 Calm
1012.7 N
1012.8 NE
1010.6 E
1012.4 SE
1013.3 S
1013.8 SW
1014.4 W
1013.2 NW
Kodiak
1029.6
1015.2
1010.3
979.5
16,995
1014.5 Calm
1009.1 N
1010.0 NE
1012.7 E
1013.4 SE
1013.9 S
1014.7 SW
1014.7 W
1013.9 NW
Cumulative Frequency (%)
Sea Level Pressure (mb)
Frequency (%)
960 980 1000 1020 1040 1060
60 50 40 30 20 10 0
0 20 40 60 80 100

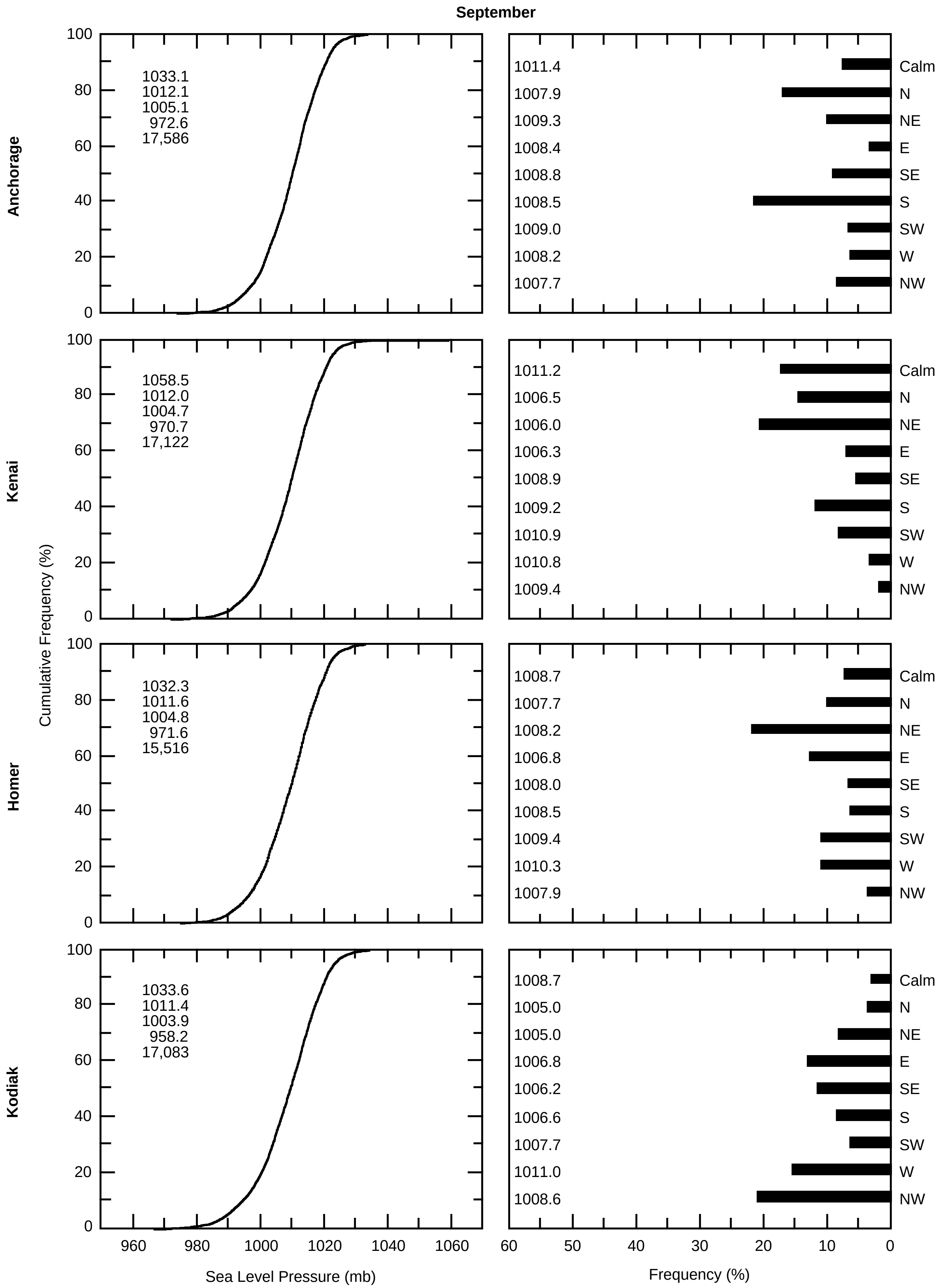
July

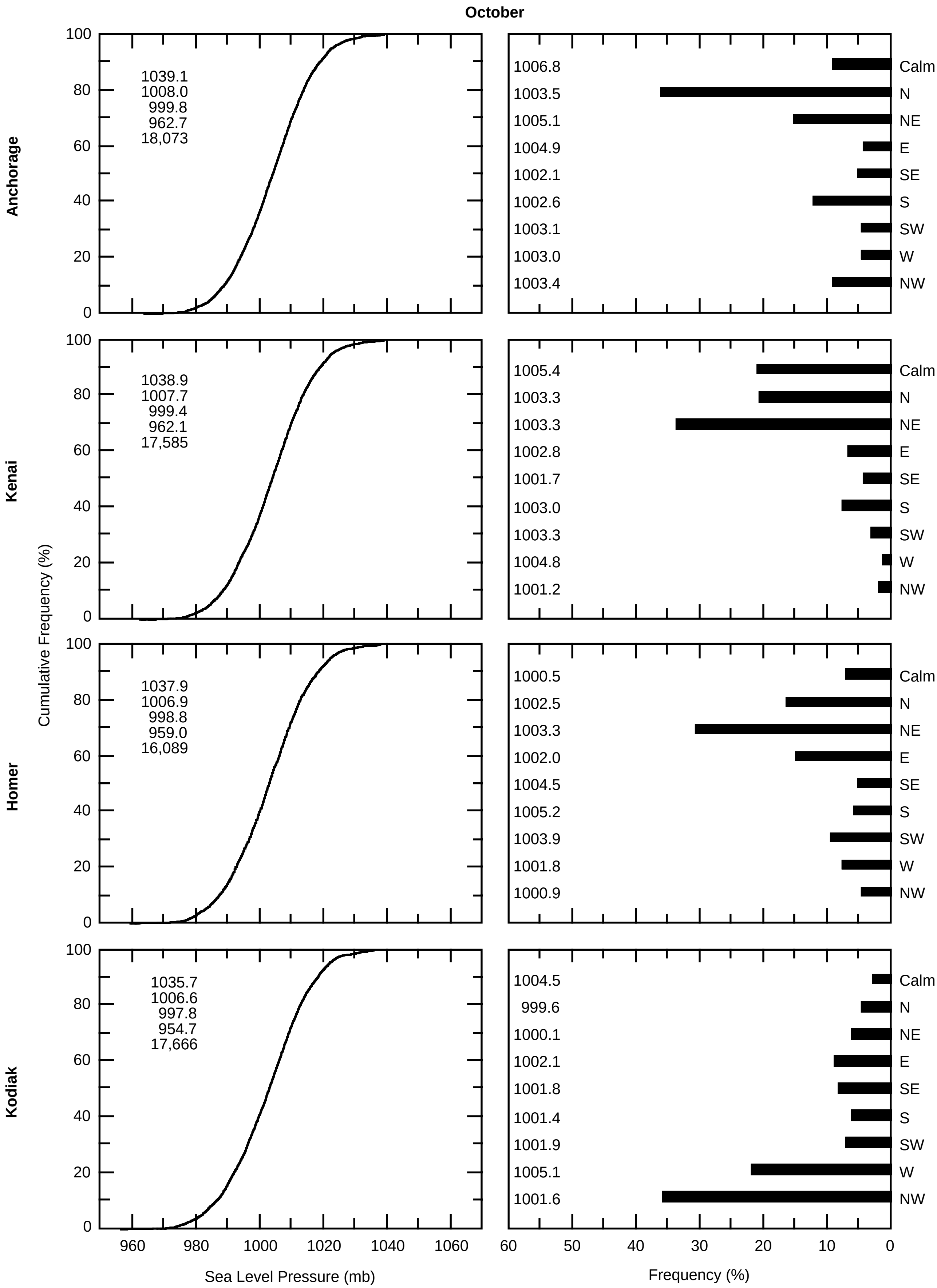

Anchorage
1032.9
1016.8
1012.7
993.5
18,170
1014.8 Calm
1014.1 N
1013.7 NE
1014.2 E
1014.1 SE
1014.3 S
1015.0 SW
1015.5 W
1015.9 NW
Kenai
1039.6
1017.0
1012.8
987.5
17,638
1015.3 Calm
1012.7 N
1012.1 NE
1012.4 E
1015.0 SE
1015.4 S
1015.7 SW
1015.5 W
1014.5 NW
Homer
1033.5
1017.1
1013.3
977.0
16,011
1015.0 Calm
1014.4 N
1015.3 NE
1014.0 E
1014.7 SE
1015.3 S
1015.4 SW
1015.9 W
1015.8 NW
Kodiak
1032.5
1017.3
1013.0
992.4
17,618
1015.8 Calm
1013.4 N
1014.4 NE
1015.1 E
1015.4 SE
1015.4 S
1015.6 SW
1016.2 W
1014.7 NW
Cumulative Frequency (%)
Sea Level Pressure (mb)
Frequency (%)
960
980
1000
1020
1040
1060
60
50
40
30
20
10
0

August

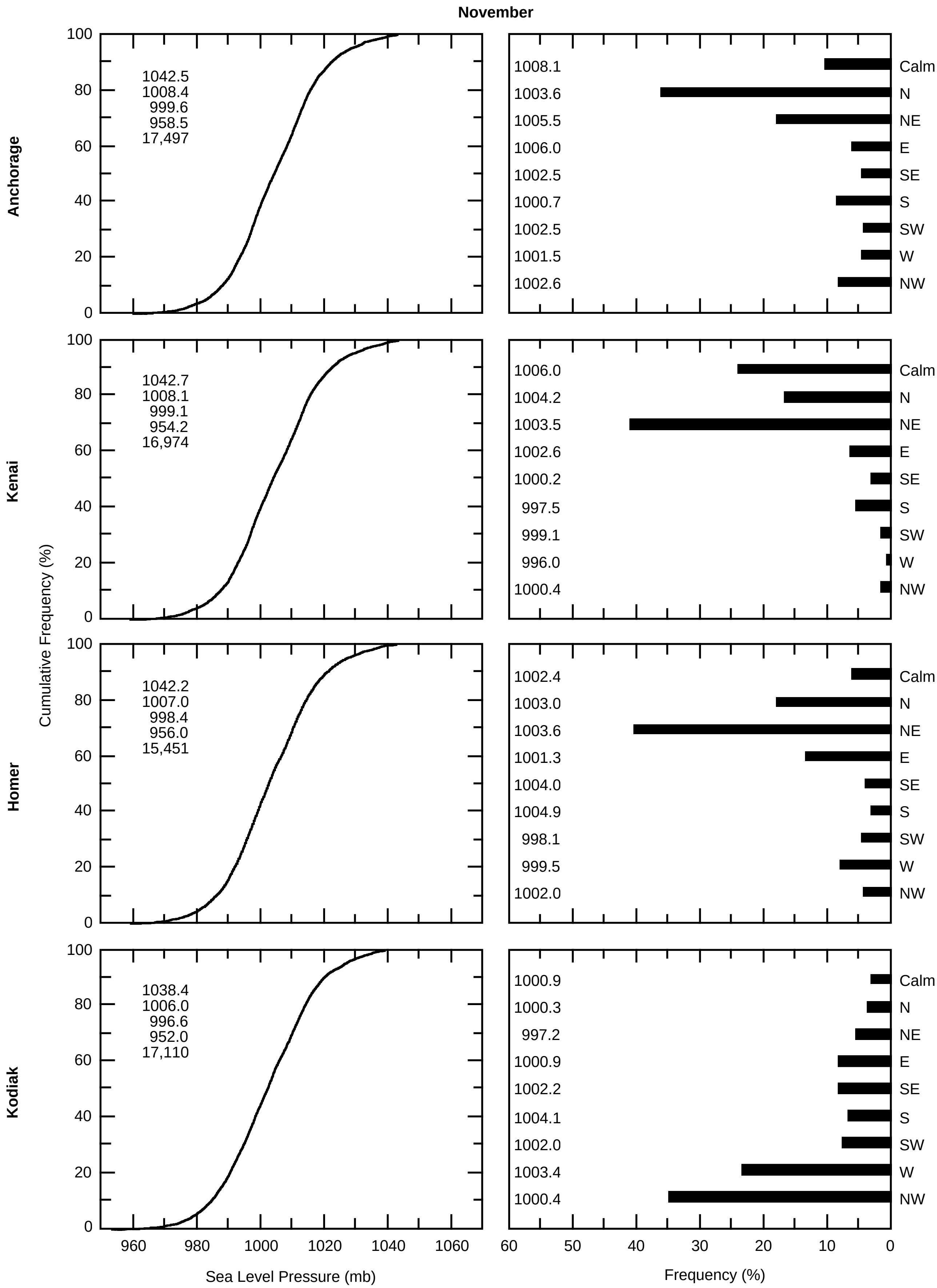


Anchorage
1033.5
1015.6
1010.9
980.8
18,141
1014.9 Calm
1011.4 N
1012.2 NE
1013.6 E
1012.1 SE
1012.7 S
1014.2 SW
1015.3 W
1014.2 NW
Kenai
1058.8
1015.7
1010.8
980.4
17,463
1014.6 Calm
1010.6 N
1009.7 NE
1011.0 E
1012.7 SE
1014.1 S
1015.1 SW
1014.8 W
1012.4 NW
Homer
1033.9
1015.7
1011.1
977.9
15,836
1013.0 Calm
1012.8 N
1014.0 NE
1012.7 E
1012.1 SE
1013.0 S
1013.6 SW
1014.3 W
1013.4 NW
Kodiak
1034.4
1016.0
1010.9
976.8
17,637
1014.3 Calm
1011.7 N
1012.9 NE
1013.6 E
1013.0 SE
1013.4 S
1013.7 SW
1014.8 W
1013.0 NW
Cumulative Frequency (%)
0
20
40
60
80
100
960
980
1000
1020
1040
1060
Sea Level Pressure (mb)
60
50
40
30
20
10
0
Frequency (%)

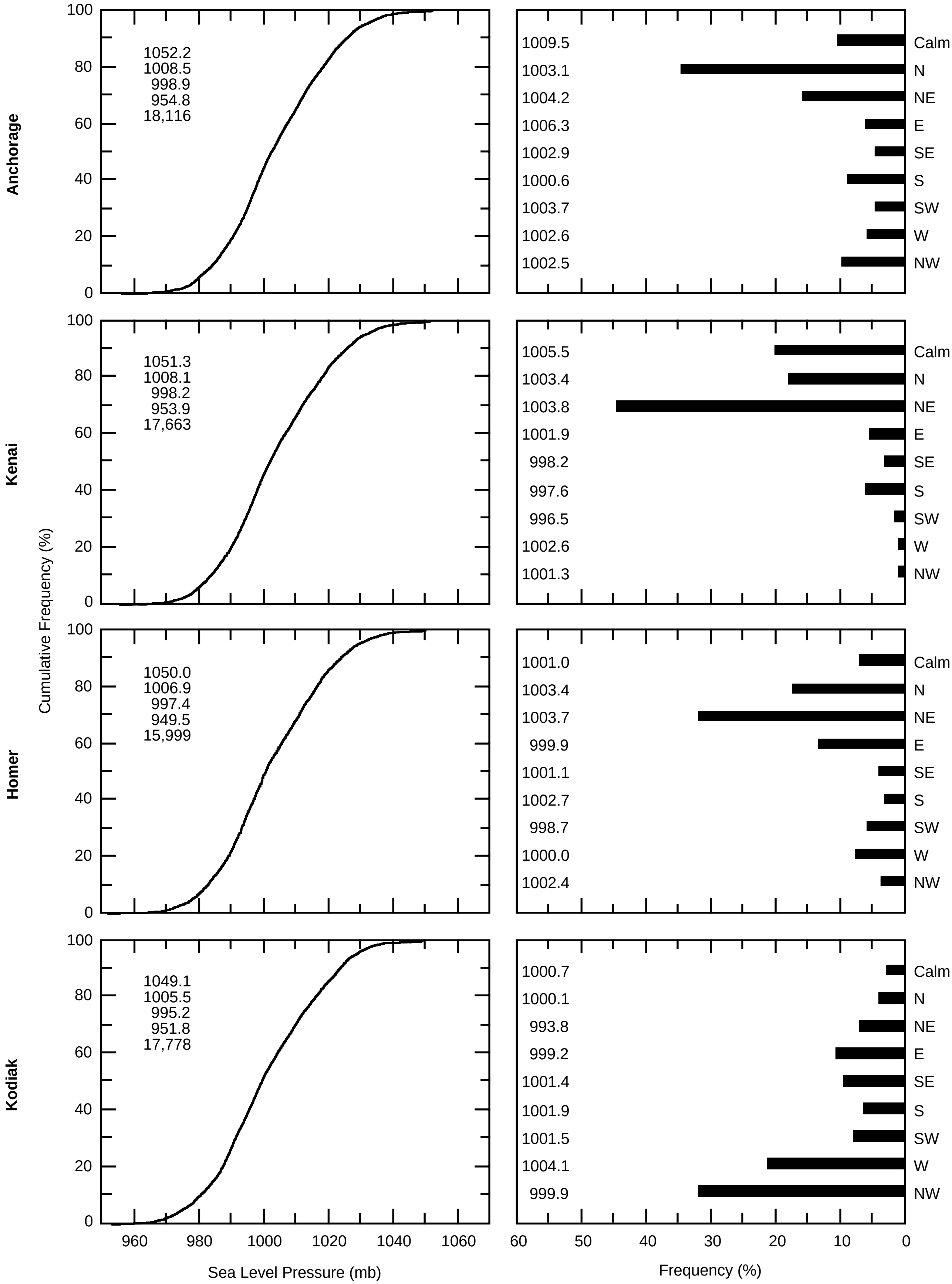

September
Cumulative Frequency (%)
Anchorage
1033.1
1012.1
1005.1
972.6
17,586
1011.4 Calm
1007.9 N
1009.3 NE
1008.4 E
1008.8 SE
1008.5 S
1009.0 SW
1008.2 W
1007.7 NW
Kenai
1058.5
1012.0
1004.7
970.7
17,122
1011.2 Calm
1006.5 N
1006.0 NE
1006.3 E
1008.9 SE
1009.2 S
1010.9 SW
1010.8 W
1009.4 NW
Homer
1032.3
1011.6
1004.8
971.6
15,516
1008.7 Calm
1007.7 N
1008.2 NE
1006.8 E
1008.0 SE
1008.5 S
1009.4 SW
1010.3 W
1007.9 NW
Kodiak
1033.6
1011.4
1003.9
958.2
17,083
1008.7 Calm
1005.0 N
1005.0 NE
1006.8 E
1006.2 SE
1006.6 S
1007.7 SW
1011.0 W
1008.6 NW
0 20 40 60 80 100
960 980 1000 1020 1040 1060
Sea Level Pressure (mb)
60 50 40 30 20 10 0
Frequency (%)



October
Anchorage
Kenai
Homer
Kodiak
Cumulative Frequency (%)
1039.1
1008.0
999.8
962.7
18,073
1038.9
1007.7
999.4
962.1
17,585
1037.9
1006.9
998.8
959.0
16,089
1035.7
1006.6
997.8
954.7
17,666
1006.8 Calm
1003.5 N
1005.1 NE
1004.9 E
1002.1 SE
1002.6 S
1003.1 SW
1003.0 W
1003.4 NW
1005.4 Calm
1003.3 N
1003.3 NE
1002.8 E
1001.7 SE
1003.0 S
1003.3 SW
1004.8 W
1001.2 NW
1000.5 Calm
1002.5 N
1003.3 NE
1002.0 E
1004.5 SE
1005.2 S
1003.9 SW
1001.8 W
1000.9 NW
1004.5 Calm
999.6 N
1000.1 NE
1002.1 E
1001.8 SE
1001.4 S
1001.9 SW
1005.1 W
1001.6 NW
0
20
40
60
80
100
960
980
1000
1020
1040
1060
Sea Level Pressure (mb)
60
50
40
30
20
10
0
Frequency (%)


November
Anchorage
1042.5
1008.4
999.6
958.5
17,497
1008.1 Calm
1003.6 N
1005.5 NE
1006.0 E
1002.5 SE
1000.7 S
1002.5 SW
1001.5 W
1002.6 NW
Kenai
1042.7
1008.1
999.1
954.2
16,974
1006.0 Calm
1004.2 N
1003.5 NE
1002.6 E
1000.2 SE
997.5 S
999.1 SW
996.0 W
1000.4 NW
Homer
1042.2
1007.0
998.4
956.0
15,451
1002.4 Calm
1003.0 N
1003.6 NE
1001.3 E
1004.0 SE
1004.9 S
998.1 SW
999.5 W
1002.0 NW
Kodiak
1038.4
1006.0
996.6
952.0
17,110
1000.9 Calm
1000.3 N
997.2 NE
1000.9 E
1002.2 SE
1004.1 S
1002.0 SW
1003.4 W
1000.4 NW
Cumulative Frequency (%)
0
20
40
60
80
100
960
980
1000
1020
1040
1060
Sea Level Pressure (mb)
60
50
40
30
20
10
0
Frequency (%)

December



Anchorage
1052.2
1008.5
998.9
954.8
18,116
1009.5 Calm
1003.1 N
1004.2 NE
1006.3 E
1002.9 SE
1000.6 S
1003.7 SW
1002.6 W
1002.5 NW
Kenai
1051.3
1008.1
998.2
953.9
17,663
1005.5 Calm
1003.4 N
1003.8 NE
1001.9 E
998.2 SE
997.6 S
996.5 SW
1002.6 W
1001.3 NW
Homer
1050.0
1006.9
997.4
949.5
15,999
1001.0 Calm
1003.4 N
1003.7 NE
999.9 E
1001.1 SE
1002.7 S
998.7 SW
1000.0 W
1002.4 NW
Kodiak
1049.1
1005.5
995.2
951.8
17,778
1000.7 Calm
1000.1 N
993.8 NE
999.2 E
1001.4 SE
1001.9 S
1001.5 SW
1004.1 W
999.9 NW
Cumulative Frequency (%)
0
20
40
60
80
100
960
980
1000
1020
1040
1060
Sea Level Pressure (mb)
60
50
40
30
20
10
0
Frequency (%)

APPENDIX H. BIBLIOGRAPHY

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14. ABSTRACT

Cook Inlet, a 350-km-long estuary located in south-central Alaska, is a region of great importance to the economy of the entire state. Approximately half the population of Alaska resides near its shores, and Anchorage, at its northern end, is the state's largest city and a focus for commerce, industry, recreation, and transportation. Tidal height variations at Anchorage are the second most extreme in the world, exceeded only by those in Canada's Bay of Fundy. Cook Inlet's extreme tidal range and the shallow bathymetry produce extreme tidal currents as well. During winter the marine ice that forms in the Inlet can have a substantial impact on human activities. This report is a compilation of previously published and unpublished information on the climatic, meteorological, oceanographic, and hydrodynamic conditions that influence the marine ice cover in Cook Inlet. Biweekly maps, based on historical conditions from 1984 through 1999, are presented that show the expected concentrations and stages of development of the ice cover. These maps were produced by re-analyzing approximately 675 archived ice charts that were produced by the National Weather Service between 1984 and 1999, using ArcView™ GIS software.

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