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A SYNOPSIS OF NEW HAMPSHIRE SEAWEEDS

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A SYNOPSIS OF NEW HAMPSHIRE SEAWEEDS[1,2]

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ABSTRACT

Species composition, phenology, longevity and distribution patterns of New Hampshire seaweed populations from diverse coastal and estuarine habitats are given. Two hundred sixteen taxa were recorded (58 Chlorophyceae, 66 Phaeophyceae and 92 Rhodophyceae), including 8 new state and/or geographical records and the recent introduction of the green alga *Codium fragile* subsp. *tomentosoides* to the Isles of Shoals. Each major group of seaweeds showed similar phenological patterns, with summer maxima and winter minima. The Rhodophyceae exhibited the greatest dominance by perennials (67.4%), the Phaeophyceae had an intermediate pattern (45.5%) and the green algae exhibited the greatest dominance by annuals (87.2%). Overall, the open coastal sites were dominated by cold temperate species, while warm temperate or "mixed floras" were more conspicuous in estuarine habitats. Varying phenological and longevity patterns were also evident in coastal and estuarine habitats. Most of the species (67%) occurred in both open coastal and estuarine habitats, while 23% were restricted to the open coast and 7% to estuarine habitats. Several unique distributional patterns were also noted, including contrasting patterns between closely related taxa, parasitic species and their respective hosts, and different life history stages of the same species. Several estuarine taxa represent disjunct populations north of Cape Cod, Massachusetts; they may be relicts of an earlier "hypsithermal" or warm period. The autecology of several disjunct taxa is discussed.

Key Words: seaweeds, coastal, estuarine, phenology and distribution, New Hampshire

[1]Scientific Contribution Number 1359 from the New Hampshire Agricultural Experiment Station; also issued as Contribution Number 130 from the Jackson Estuarine Laboratory.

[2]This paper is dedicated to Dr. Robert F. Scagel on the occasion of his academic retirement and in recognition of his outstanding and pioneering efforts in marine phycology, particularly of the Pacific Northwest.

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INTRODUCTION

Until recently there have been few published accounts of New Hampshire (Figures 1–4) seaweeds. Farlow (1882) and Collins (1900, 1901, 1903 and 1906a) compiled the earliest records for the state; subsequently, Croasdale (1941) listed a few additional records, primarily from the Isles of Shoals (Figure 2). Wood and Straughan (1953) described the penetration of the freshwater red alga *Sacheria fucina* (as *Lemanea fucina*) within the tidal portions of the Oyster River (Figure 3). Doty and Newhouse (1954) recorded several collections from the Great Bay Estuary System (Figure 3) and noted a conspicuous decrease in species numbers from the mouth to the head of the estuary. Taylor (1957) summarized many of the earlier records for New Hampshire and adjacent New England states in his excellent account of the benthic marine flora of northeastern North America.

Since 1965, a variety of floristic, phenological and ecological studies of New Hampshire's (Figures 1–4) marine algal flora have been conducted by phycologists at the University of New Hampshire. Hehre and Mathieson (1970) described the species composition, seasonal occurrence and reproductive periodicity of 88 taxa of red algae from various open coastal and estuarine environments. Similar floristic and phenological data were recently summarized on the Phaeophyceae (Mathieson and Hehre, 1982) and Chlorophyceae (Mathieson and Hehre, 1983). The seasonal occurrence and vertical distribution of 125 seaweeds at Jaffrey Point (Fort Stark), New Castle, New Hampshire were recorded (Mathieson, Hehre and Reynolds, 1981), as well as the distributional patterns of marine algae within the Great Bay and Hampton-Seabrook (Figures 3 and 4) estuary systems (Mathieson, 1975; Mathieson and Fralick, 1972; Mathieson, Reynolds, and Hehre, 1981). Each of the estuarine areas showed a "typical" reduction pattern inland, as well as the importance of tidal rapids in determining local and discontinuous distributional patterns. A comparison of the species composition of seaweeds from the Merrimack River estuary (Figure 1), Massachusetts, (Mathieson and Fralick, 1973) with that of the Hampton-Seabrook and the Great Bay estuary systems (see earlier citations) indicates a paucity of total species and number of taxa/station in the Merrimack River estuary—one of the most polluted rivers in New England (Jerome et al., 1965; Miller et al., 1971). In contrast, tidal

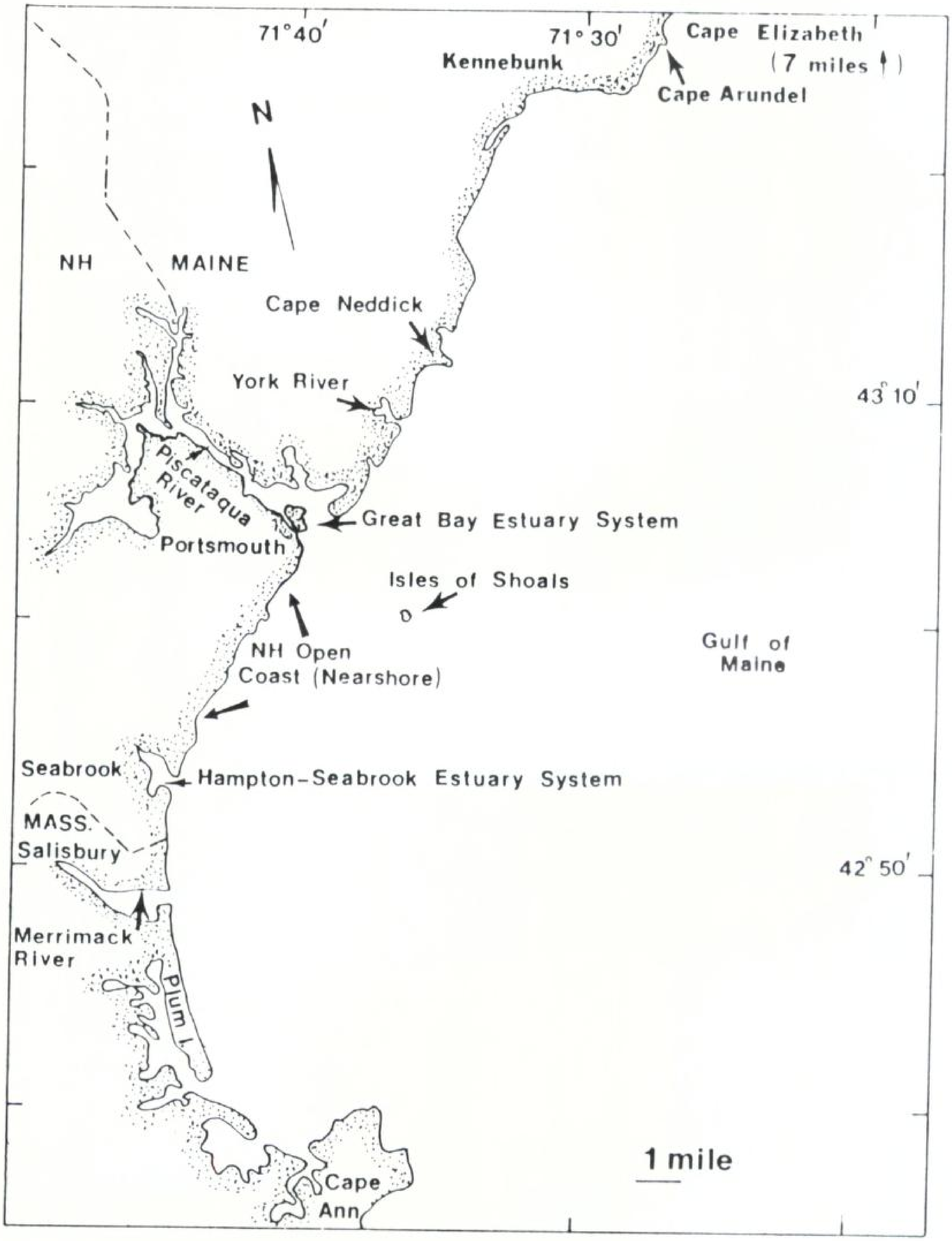

Figure 1. The New England coastline between Cape Arundel, Maine and Cape Ann, Massachusetts, including the four primary coastal-estuarine areas within New Hampshire.

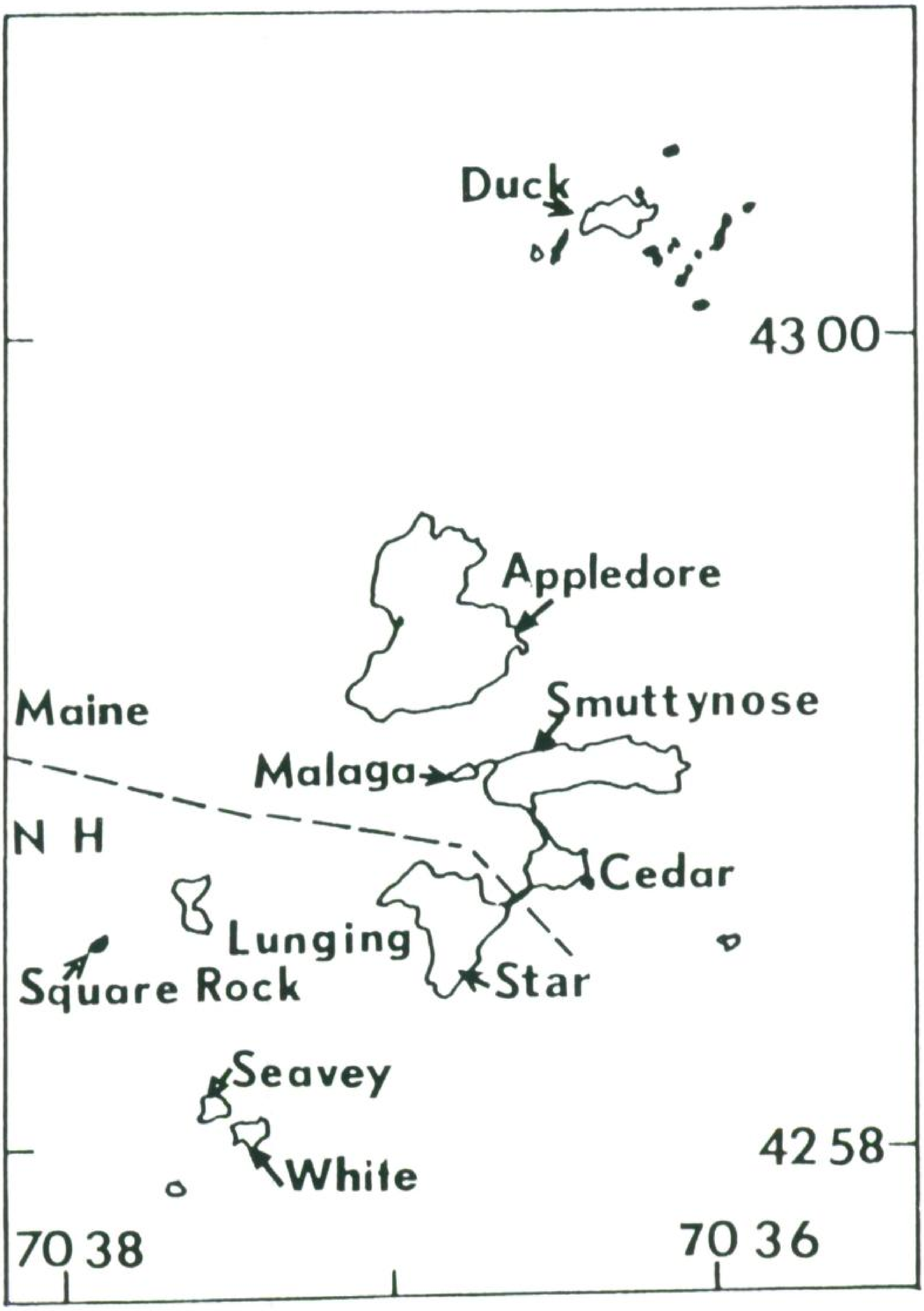

Figure 2. The Isles of Shoals, New Hampshire–Maine.

rapid sites such as Dover Point, which occur within the Great Bay Estuary System (Figure 3), can exhibit a much greater diversity of species than the entire Merrimack River (Mathieson, Neefus and Emerich Penniman, 1983; Mathieson and Fralick, 1973; Reynolds and Mathieson, 1975). Tidal rapids also exhibit a more diverse flora than adjacent "back-eddy" sites, and such rapids may represent major phytogeographic boundaries within estuaries (Mathieson, Reynolds and Hehre, 1981).

A comparative phytogeographic evaluation of seaweed populations at the Isles of Shoals (Figure 2), an archipelago of eight major offshore islands near southern Maine and New Hampshire, showed that the mean similarity within the Shoals was approximately 82% and that a significant proportion of the variance in species richness per island was explained by the length of semi-exposed shoreline on each island (Mathieson and Penniman, 1986a). Detailed studies of the subtidal flora of New Hampshire were initiated by SCUBA diving on the open coast and within the Great Bay Estuary System (Mathieson, 1975, 1979; Mathieson and Burns, 1970; Mathieson, Hehre and Reynolds, 1981). The species richness, longevity and vertical distribution of the subtidal seaweed populations were related to a variety of environmental parameters, including temperature, salinity, light and water motion. Additional descriptive accounts of New Hampshire algae have been given by Normandeau Associates (1971–1980) for the Piscataqua River near the Schiller Power Plant, by the New Hampshire Department of Fish and Game (Nelson et al., 1981, 1982) for the Great Bay Estuary System, and by Daly and Mathieson (1977) at Bound Rock in Seabrook. Several additional biosystematic (Blair, 1983; Blair et al., 1982), floristic (Hehre, 1972) and autecological investigations of New Hampshire seaweeds have been conducted (Burns and Mathieson, 1972a, b; Chock and Mathieson, 1976, 1983; Daly and Mathieson, 1977; Hardwick-Witman and Mathieson, 1983; Josselyn and Mathieson, 1978, 1980; Kilar and Mathieson, 1978, 1981; Mathieson, 1979, 1982a; Mathieson and Burns, 1975; Mathieson, Neefus and Emerich Penniman, 1983; Mathieson, Penniman, Busse and Tveter-Gallagher, 1982; Mathieson and Prince, 1973; Mathieson, Shipman, O'Shea and Hasevlat, 1976; Niemeck and Mathieson, 1976; Norall et al., 1981; Sideman and Mathieson, 1983a, b, 1985; Tveter and Mathieson, 1976; Tveter-Gallagher and Mathieson, 1980; Tveter-

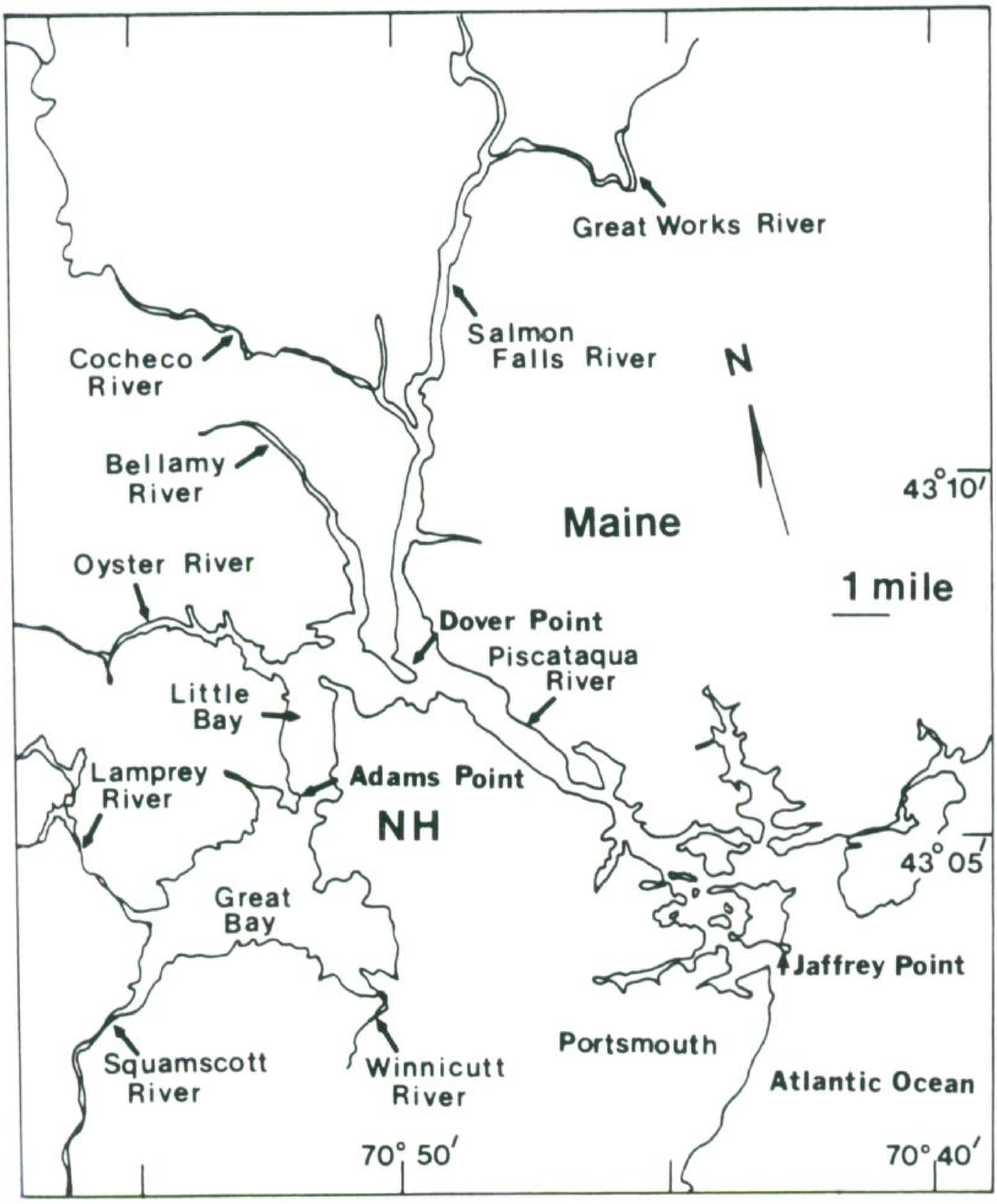

Figure 3. The Great Bay Estuary System and the adjacent open coast of New Hampshire–Maine.

Gallagher, Mathieson and Cheney, 1980; Zechman and Mathieson, 1985).

In the present account, a synopsis of the Chlorophyceae, Phaeophyceae and Rhodophyceae from coastal/estuarine habitats in New Hampshire is given, based upon a synthesis of the above-described collections and data. The phenology, longevity and local distribu-

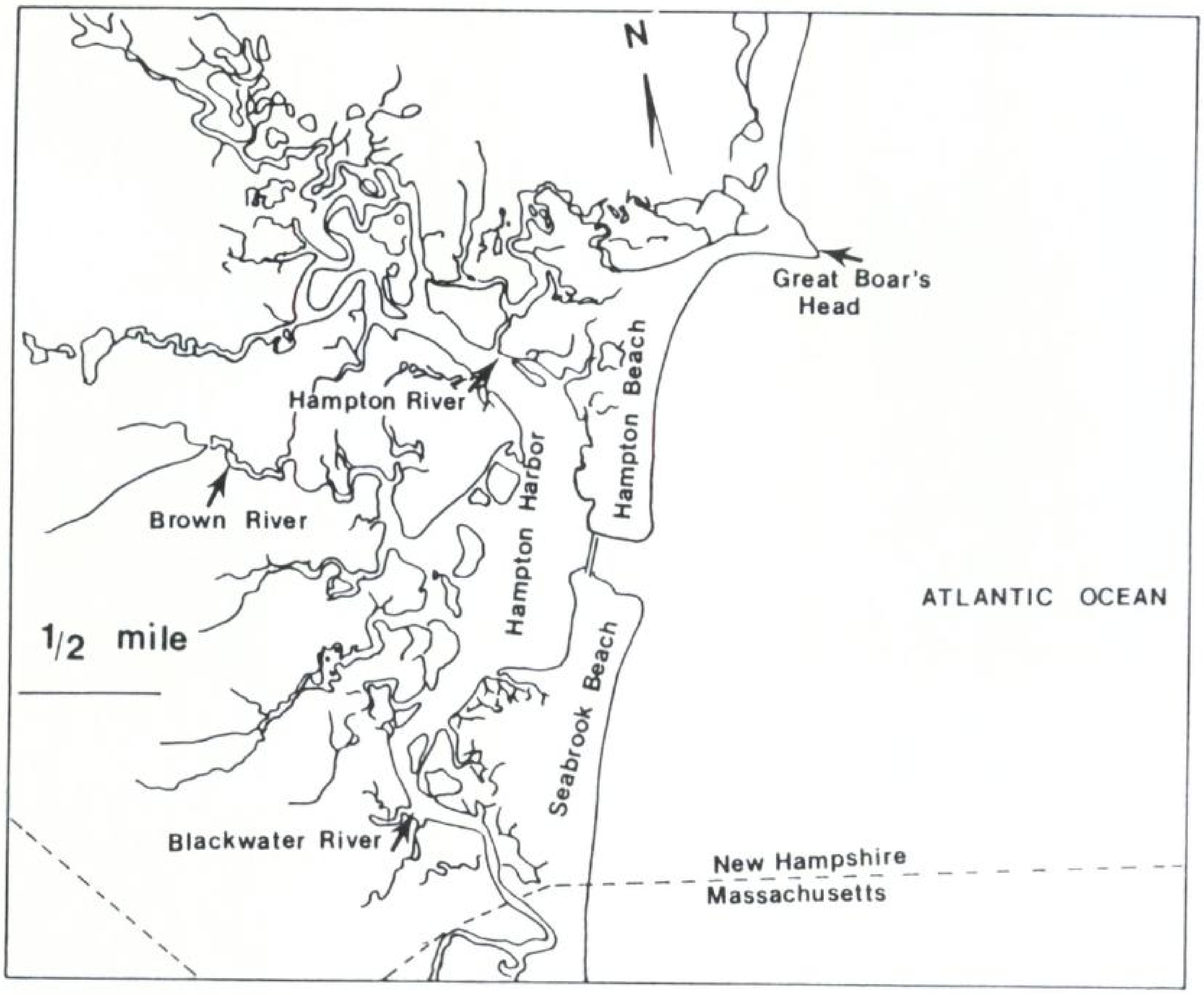

Figure 4. The Hampton-Seabrook Estuary System and the adjacent open coast of New Hampshire and Massachusetts.

tional patterns of each taxon are summarized in a series of detailed distribution maps. Norton (1978), among others, has emphasized that distributional maps are significant tools in marine ecology, particularly if a comprehensive set of environmental data is available. A detailed synopsis of the New Hampshire coastal zone is given to aid in such geographical and ecological comparisons.

METHODS AND MATERIALS

As outlined previously, extensive collections and observations of New Hampshire seaweeds have been made at a variety of open coastal and estuarine sites (Figure 5, Table IV and Appendix) during 1965–83 in order to prepare a detailed synopsis of the state's marine algal flora. Thus, collections were made at 212 study sites,

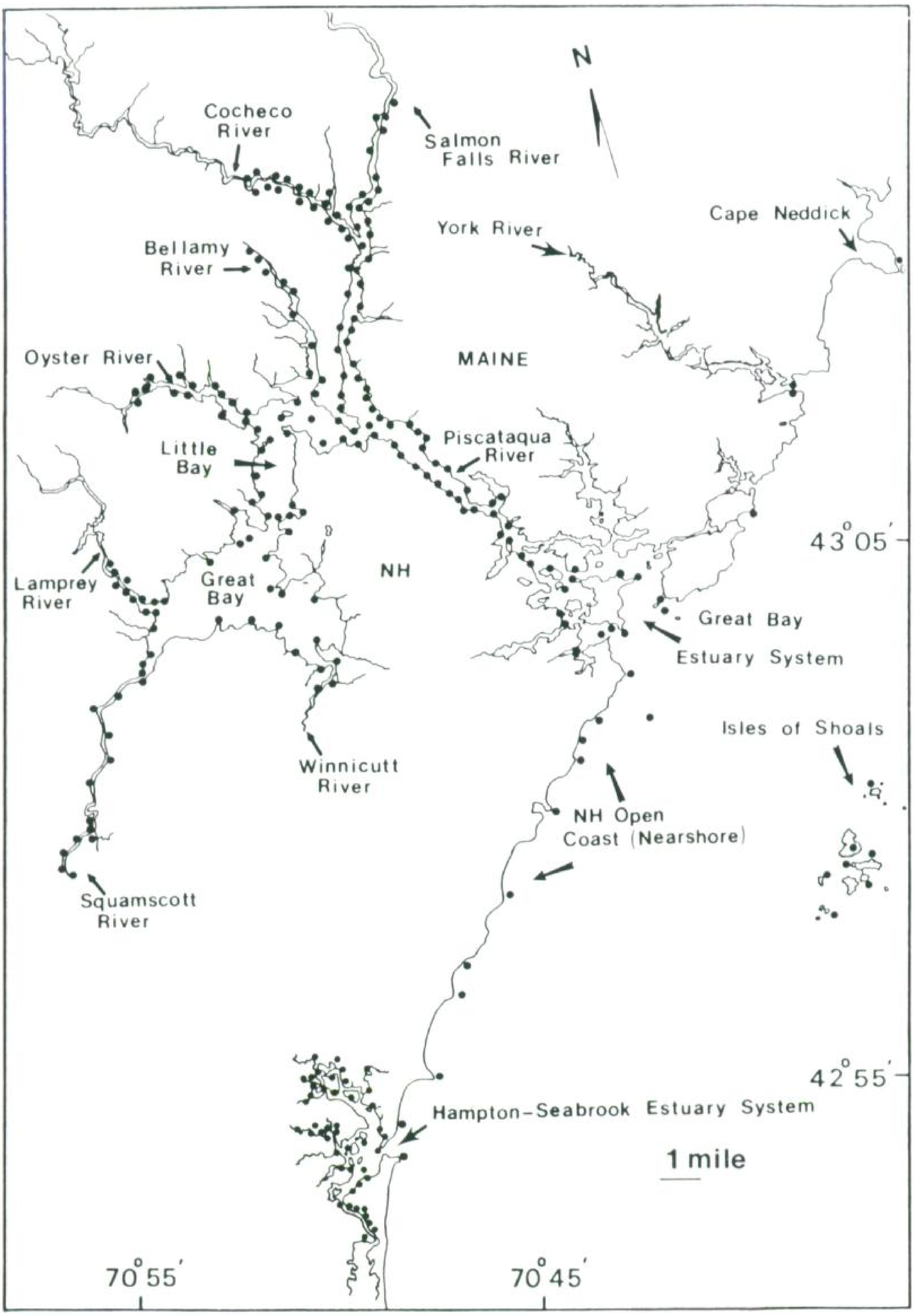

Figure 5. Summary of 256 collecting sites in New Hampshire and southern Maine.

including 23 locations where a minimum of 2 years of monthly collections were made. Forty-nine stations were studied in the Hampton-Seabrook Estuary, New Hampshire, during the summer and fall of 1969 (Mathieson and Fralick, 1972), including collections from the five major rivers and creeks, Hampton Harbor and the adjacent open coast near Hampton. Thirteen sites from the nearshore open coast between Portsmouth and Seabrook were documented, as well as the species composition at three of the nine major islands at the Isles of Shoals (Mathieson and Penniman, 1986a). One hundred forty-seven collection sites were studied within the Great Bay Estuary System, including Great Bay, Little Bay, the Bellamy, Cocheco, Lamprey, Oyster, Piscataqua, Salmon Falls, Squamscott and Winnicut Rivers. Collections were also made at 44 adjacent coastal and estuarine sites in Maine (Figure 5, Table IV and Appendix).

Representative samples of all conspicuous species at each site (Table IV and Appendix) were made in the littoral (on foot) and sublittoral zones (by SCUBA). Methods of collection, identification and processing of samples were similar to those outlined by Hehre and Mathieson (1970) and Mathieson, Hehre and Reynolds (1981). Monthly collections for at least 2 years were made at 23 sites ranging from the nearshore open coast of New Hampshire through the entire Great Bay Estuary System, including its tidal tributaries (Table IV and Appendix). Intermittent or seasonal collections were made at the other 233 sites (i.e., including 44 Maine stations). Herbarium voucher specimens of each taxon/site were prepared and deposited in NHA. The complete set of approximately 40,000 specimens is deposited in order to document temporal and spatial characteristics of the state's marine algal flora. The primary source of identification was Taylor (1957); even so, several other monographs (*see* Mathieson, Hehre and Reynolds, 1981, for a partial listing) and the recent nomenclatural changes summarized by South (1984) were also employed.

THE NEW HAMPSHIRE COASTAL ZONE

The New Hampshire coastline is located approximately midway between Cape Elizabeth, Maine, and Cape Ann, Massachusetts

(Figure 1). Many geological-topographical characteristics are common to this coastal region, including the general absence of offshore islands, the presence of sandy barrier beaches in front of extensive salt marshes, and the occurrence of large rocky headlands or promontories.

As shown in Figures 1–4, the state's coastal zone consists of four primary areas:

1. Isles of Shoals
2. seventeen miles of nearshore open coast and adjacent salt marshes
3. Hampton-Seabrook Estuary System
4. Great Bay Estuary System

The Isles of Shoals are located approximately 9 miles SSE of the mouth of the Piscataqua River and 6.5 miles due east of Straw Point, Rye (Figures 1 and 2). The islands oocupy an area 3 miles north-south by 1.5 miles east-west and lie between the coordinates 42°59′N, 70°37′20″W and 43°00′30″N, 70°36′W. There are nine major islands: five are under the jurisdiction of the Town of Kittery, Maine (Appledore, Cedar, Duck, Malaga, and Smuttynose), and four are within Rye, New Hampshire (Lunging, Seavey, Star and White). Nine other rocks and ledges are present in the Island group (Anderson, Eastern, Halfway, Mingo, Shag and Square Rocks, plus Cedar and White Islands Ledges and Southwest Ledge). The Isles of Shoals are massive granitic outcrops, the north and east sides of which are exposed to extreme wave action, particularly during storms. The west and south sides of the islands are more sheltered, such as, Gosport Harbor on the leeward side of Star Island. Mathieson and Penniman (1986a) and Norall et al. (1981) give a variety of other details regarding the physical-environmental characteristics of the Shoals.

The southern boundary of New Hampshire's nearshore open coast (Figures 1 and 4) is at Seabrook (42°52′30″N, 70°49′W), while the northern boundary is at the mouth of the Piscataqua River near the entrance to Portsmouth Harbor (43°04′20″N, 70°42′42″W). Extensive salt marshes occur along this coast, particularly near Rye, Portsmouth and Hampton. Three major habitats are found on the nearshore open coast: cobble-boulder, exposed headlands, and sandy beaches (*see* Hehre and Mathieson, 1970, for further descriptions). The metamorphic headlands at Rye Ledge and Great Boars

Head are exposed to extreme wave action. The most extensive sandy beaches are found in the Hampton and Seabrook areas.

The Hampton-Seabrook Estuary (Figure 4) is located entirely within the State of New Hampshire, between latitudes 42°51′30″N to 42°55′55″N and longitudes 70°49′30″W to 70°51′30″W. This estuary is within the townships of Hampton, Hampton Falls and Seabrook, and has a total area of about 3,800 acres. Five rivers (Taylor, Hampton, Hampton Falls, Brown and Blackwater), as well as a variety of smaller creeks and brooks are present within this estuary.

The Great Bay Estuary System occurs within New Hampshire and Maine (Figure 3). It consists of Great Bay, Little Bay, the Piscataqua River, Portsmouth Harbor and its tributaries, as well as seven other freshwater rivers (Bellamy, Cocheco, Lamprey, Oyster, Salmon Falls, Squamscott and Winnicut), which drain into the basin. The Great Bay Estuary System is one of the largest estuaries on the eastern seaboard of the United States, with over 11,000 acres of tidewater (Anon., 1960). The total drainage area of the estuary is approximately 930 square miles, two-thirds of which is within New Hampshire (Anon., 1960). The estuary contains about 100 miles of shoreline. The substratum in the Great Bay Estuary System, as well as the Hampton-Seabrook Estuary, is dominated by mud (Hardwick-Witman and Mathieson, 1983); occasional rock outcrops, cobbles, shells and artificial structures such as pier pilings are also present. Overall, the substratum within the Hampton-Seabrook Estuary is more sandy than the Great Bay Estuary System, particularly toward Hampton Harbor.

The seasonal patterns of surface water temperatures on the nearshore open coast of New Hampshire and within the Great Bay Estuary System are illustrated in Figure 6. Typically, the maximum temperatures occur during mid-summer through the fall. Thereafter, temperatures decrease rapidly, particularly in the inner estuary, with lowest values occurring January to March. Open coastal site have a narrower temperature range than estuarine sites. For example, surface water temperatures at the Isles of Shoals vary from 3.8° to 18.2°C, versus −1.0° to 19.0°C at Portsmouth Harbor, −2.0° to 24.1°C at Dover Point, −1.8° to 26.5°C at Adams Point, and −2.0° to 27.0°C within Great Bay proper (Emerich Penniman et al., 1985; Norall and Mathieson, 1976; Norall et al., 1982). Even

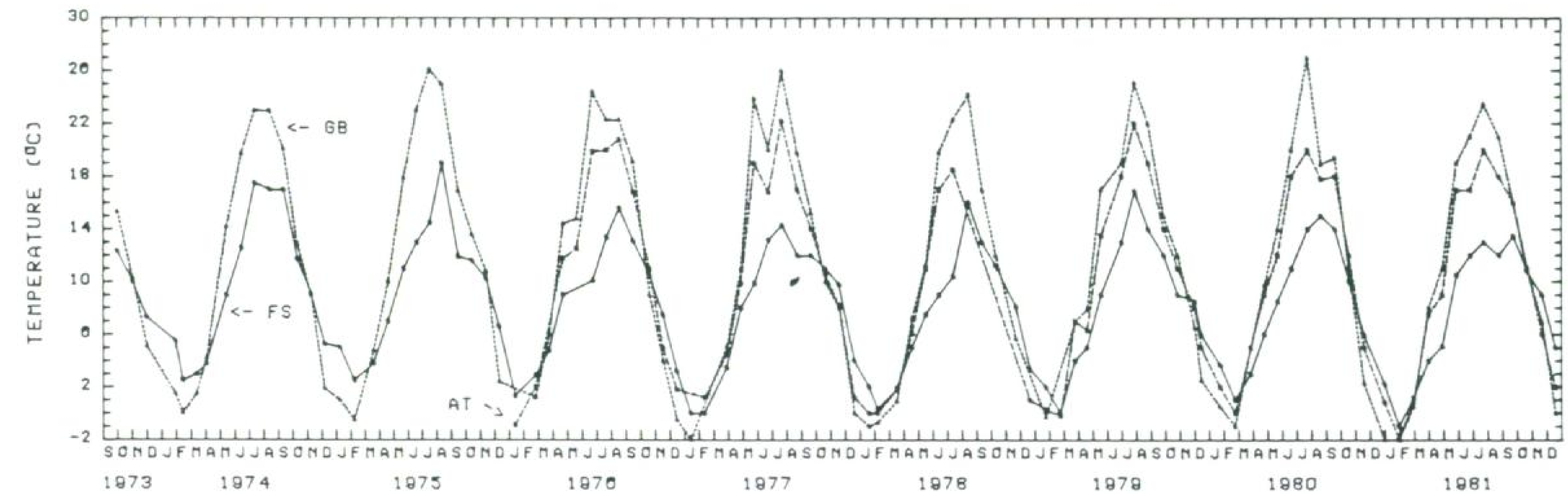

Figure 6. Seasonal variation of surface water temperature on the nearshore open coast of New Hampshire (Jaffrey Point, Fort Stark) and within the Great Bay Estuary System (Atlantic Terminal and Great Bay) during 1973–1981 (based upon Emerich Penniman et al., 1985).

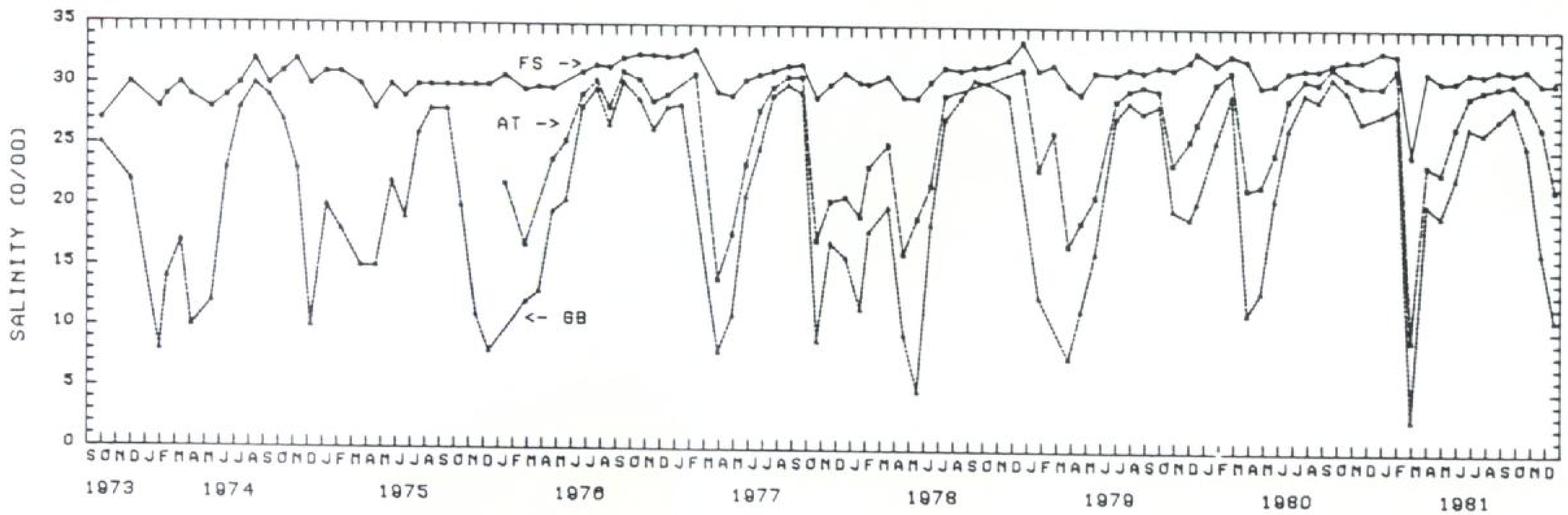

Figure 7. Seasonal variation of surface water salinities on the nearshore open coast of New Hampshire (Jaffrey Point, Fort Stark) and within the Great Bay Estuary System (Atlantic Terminal and Great Bay) during 1973–1981 (based upon Emerich Penniman et al., 1985).

greater variations (daily and seasonally) of temperatures are present within riverine habitats of the Great Bay Estuary System. Daly and Mathieson (1979, 1981), Daly et al. (1979), Emerich Penniman et al. (1985), Glibert (1976), Loder et al. (1979), Norall and Mathieson (1976), Norall et al. (1982), and Silver and Brown (1979) all gave details regarding temperature and salinity variations within the same geography. Overall, there is a pattern of greater variation as well as increasing mean surface water temperatures from the open coast to the inner estuary (Figure 8).

The seasonal patterns of surface water salinities on the nearshore open coast of New Hampshire and within the Great Bay Estuary System are illustrated in Figure 7. Typically, the maximum salinities occur in the summer and fall, while the lowest salinities occur during January to early spring—i.e., during winter and spring thaws. As with temperatue, the most pronounced salinity variations occur within inner estuarine sites, while adjacent open coastal areas are more stable. For example, the surface water salinities at the Isles of Shoals range from 31.0–33.0‰, while greater variations are evident at Portsmouth Harbor (24.6–33.8‰), Dover Point (0.9–30.3‰), Adams Point (6.6–31.4‰), and within Great Bay proper (2.7–30.97‰) (Emerich Penniman et al., 1985; Norall and Mathieson, 1976; Norall et al., 1982). Overall, there is a pattern of increased salinity variation (daily and seasonally), as well as a clinal decrease in surface water salinities, from the open coast of New Hampshire to the inner estuary (Figure 8).

A foot or more of ice is usually present from late December to March in Great Bay and the major tidal rivers (except the Piscataqua) within the Great Bay Estuary System. The scouring effects of ice are evident on rocks, pier pilings and other solid substrata. Large sections of marshy shoreline may be torn loose (rafted) during the spring thaw (Hardwick'Witman, 1985; Mathieson, Penniman, Busse and Tveter-Gallagher, 1982). Floating ice rafts and icebergs can often be seen on the adjacent open coast (Jaffrey Point) during the spring thaw.

The water transparency at the Isles of Shoals is much greater than in Portsmouth Harbor, which in turn is greater than that within the Great Bay Estuary System (Daly et al., 1979). The depth of penetration of light (1%) in the sea determines the lower limits of plant distribution along this natural gradient (Figure 8). Thus, attached

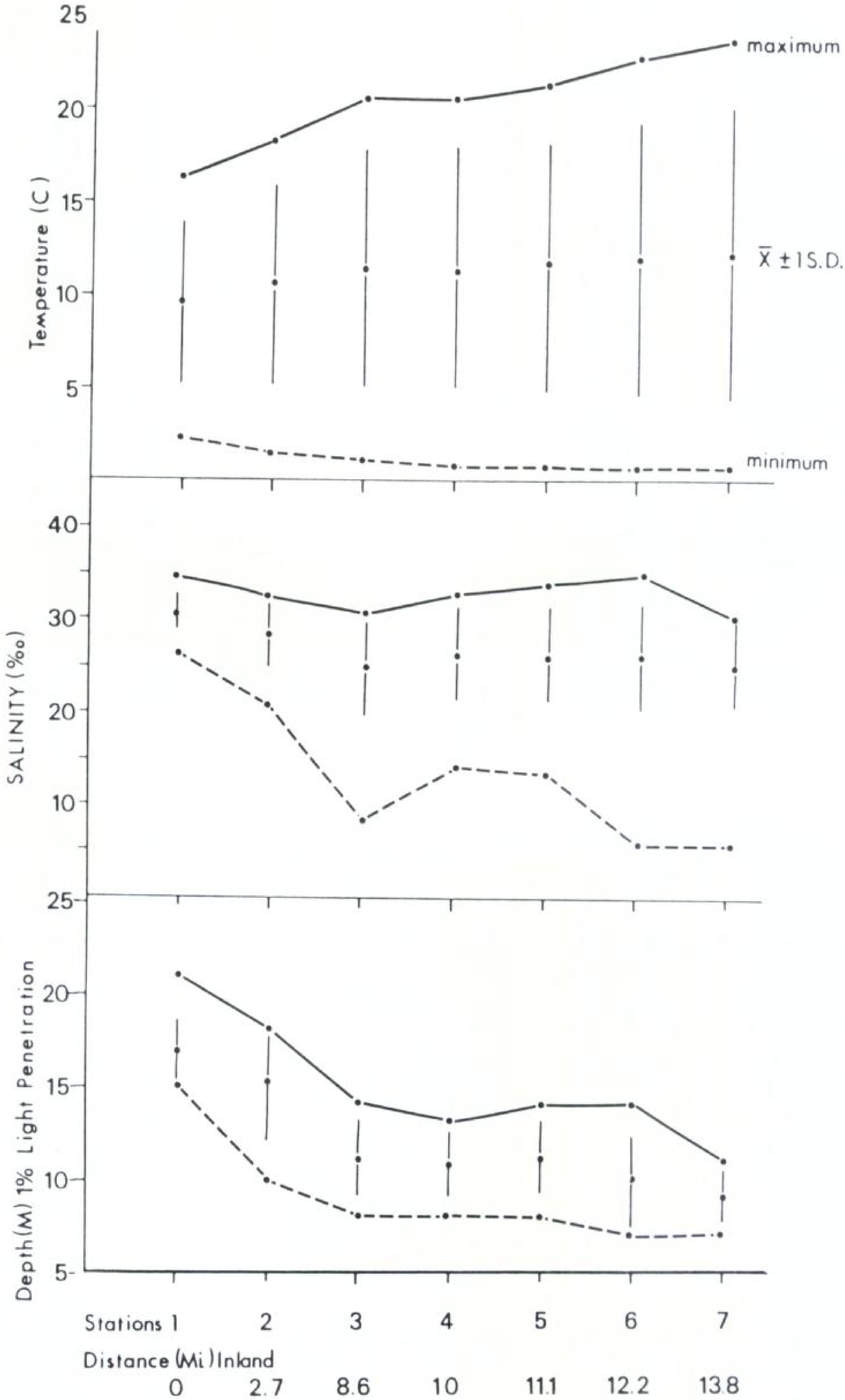

Figure 8. Mean values of surface water temperatures, salinities and 1% light penetration on the nearshore open coast of New Hampshire and within the Great Bay Estuary System during 1974–1978 (based upon Daly et al., 1979).

marine plants which require light to photosynthesize are found at 100–125 feet at the Shoals, 60–80 feet near the mouth of Portsmouth Harbor, and 10–15 feet in the upper parts of Great Bay proper (Figure 9). The differential water clarity of the estuary is primarily related to the volume of silt and organic material (detritus) in the latter habitat (Daly et al., 1979; Norall and Mathieson, 1976; and Norall et al., 1982).

Differential levels of nutrients (nitrogen and phosphorus) are evident on the open coast of New Hampshire and within the Great Bay Estuary System (Figures 10 and 11), with lower values occurring in the former areas (Norall and Mathieson, 1976; Norall et al., 1982). In general, nutrients are highest during the winter months from December into March; thereafter, a sharp decline occurs due to the spring bloom of phytoplankton. Intermediate levels are usually found during the summer, and they begin to increase during the fall. A detailed tabulation of seasonal and spatial variations of ni-

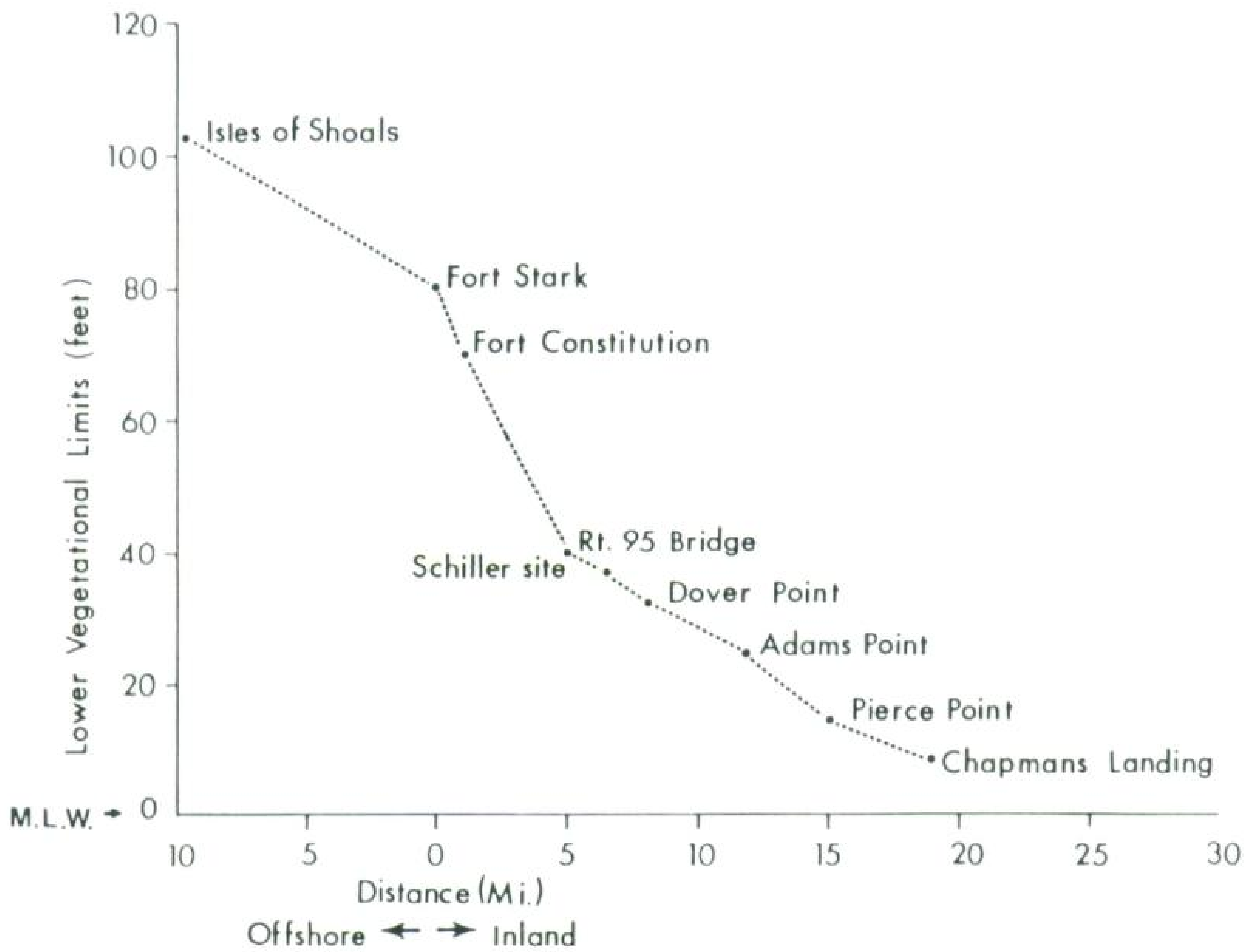

Figure 9. The lower limits of subtidal plant distribution between the Isles of Shoals and the inner reaches of the Great Bay Estuary System.

trogenous, phosphorous, and silicious nutrients within the Great Bay Estuary System and the adjacent open coast of New Hampshire is given by Norall and Mathieson (1976), Norall et al. (1982), and Emerich Penniman et al. (1985). Additional nutrient data for the same area are summarized by Burns and Mathieson (1972b), Glibert (1976), Loder and Glibert (1977, 1980), Loder et al. (1979), Lyons, Loder and Murray (1982), Mathieson and Burns (1975) and Mathieson and Tveter (1975).

The average tidal amplitude at the Shoals and near Portsmouth Harbor is about 8.1 feet, while it is about 6.8 feet at the head of Great Bay proper (Anon., 1965). Two high and two low tides occur each day in the coastal zone, and they are uniformly semi-diurnal. Tides cause considerable fluctuations of water transparency, temperature, salinity and current speeds, particularly in estuarine habitats (Daly and Mathieson, 1979). Tidal currents are a conspicuous feature of the Great Bay Estuary System (Figure 3), particularly in narrow channels near Adams Point, Dover Point, Fox Point, and the lower Piscataqua River (Brown and Arrellano, 1979; Celikkol and Reichard, 1976; Mathieson, Neefus, and Emerich Penniman, 1983; Mathieson, Reynolds, and Hehre, 1981; Mathieson, Tveter, Daly and Howard, 1977; Reynolds and Mathieson, 1975; Schmidt, 1980; Swenson et al., 1977; Trask and Brown, 1980). In such habitats tidal currents of 4–6 knots are evident, with maximum currents occurring during ebb tide (Figure 12). All of the tidal waters of the Great Bay Estuary System enter and leave via the Piscataqua River, creating strong tidal currents.

Domestic pollution is moderate within the Great Bay Estuary System. Treated effluent (chlorinated and settled) is discharged from the towns of Dover, Durham, Exeter, Newmarket and Rochester. Occasionally, raw sewage may be discharged during extreme storm periods when some sewage treatment plants (Dover) cannot handle the volume. Industrial pollution (heavy metals and organic sludge) is discharged from Dover, Rochester and Portsmouth (Capuzzo and Anderson, 1973; Hines et al., 1984; Lyons, Armstrong, O'Neil and Gaudette, 1982). Little industrial pollution occurs in the Hampton-Seabrook Estuary. On the open coast of New Hampshire, little pollution from domestic and industrial sources occurs, except for a few "point sources" of domestic discharges in Rye and other areas. The Isles of Shoals represent a relatively "pristine" coastal environment.

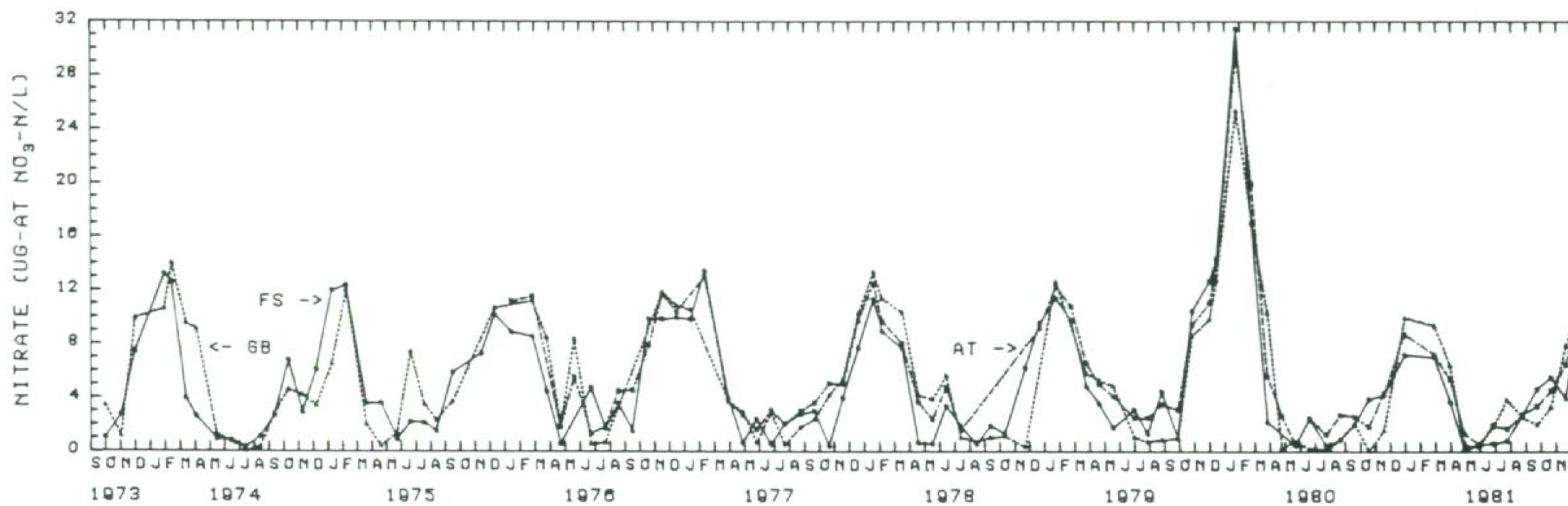

Figure 10. Seasonal variation of nitrogenous-nutrient levels (i.e. nitrate-N) on the nearshore open coast of New Hampshire (Jaffrey Point, Fort Stark) and within the Great Bay Estuary System (Atlantic Terminal and Great Bay) during 1973–1981 (based upon Emerich Penniman et al., 1985).

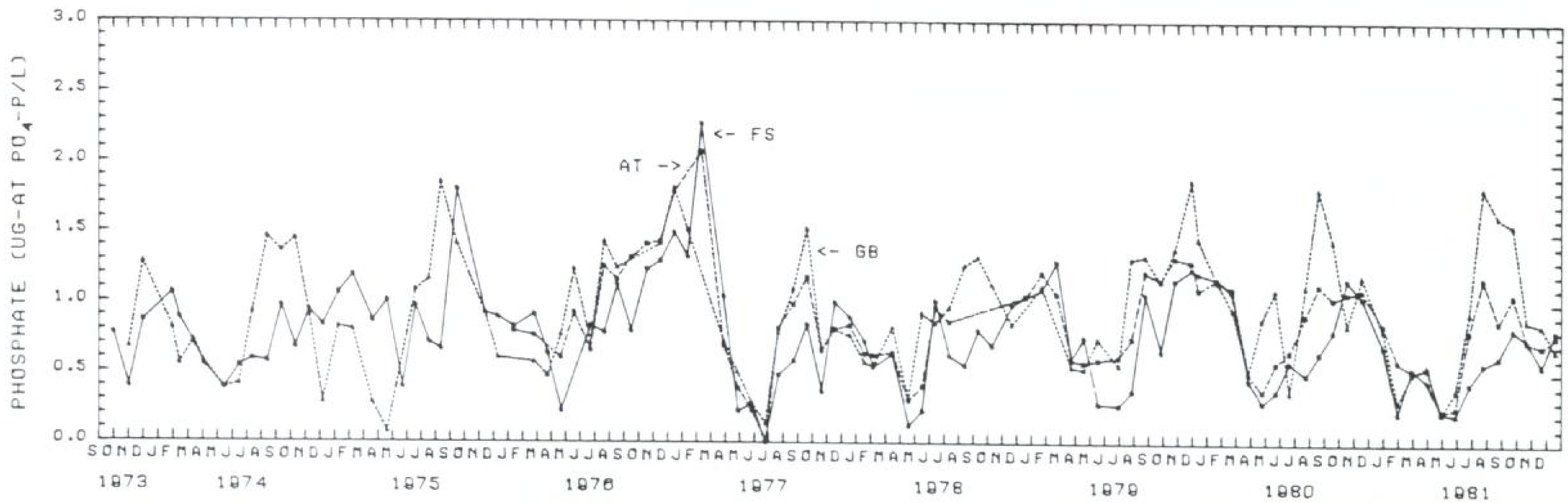

Figure 11. Seasonal variation of phosphorous-nutrient levels (i.e. orthophosphate-P) on the open coast of New Hampshire (Jaffrey Point, Fort Stark) and within the Great Bay Estuary System (Atlantic Terminal and Great Bay) during 1973–1981 (based upon Emerich Penniman et al., 1985).

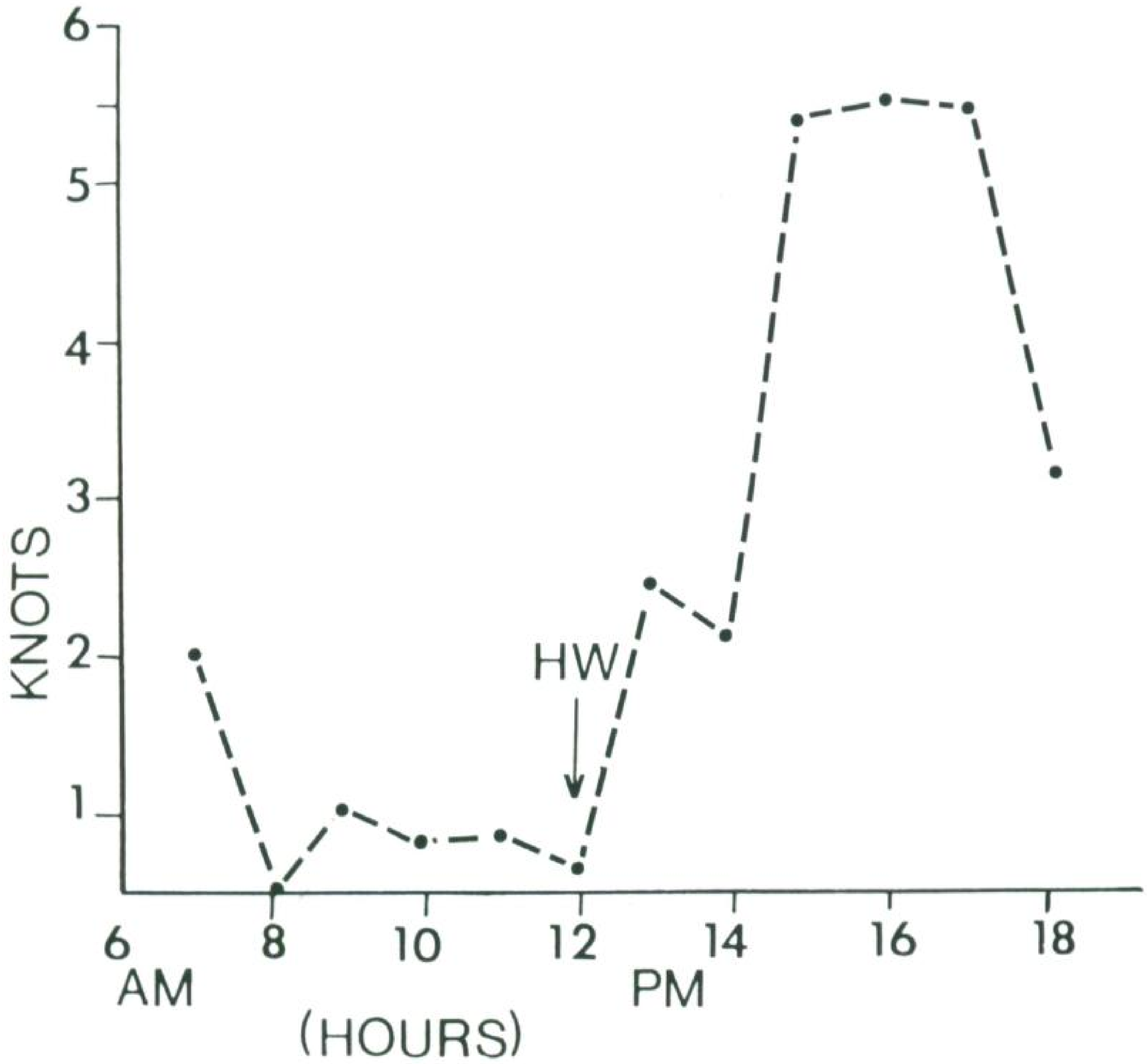

Figure 12. Diurnal variations of tidal currents at Dover Point.

SPECIES COMPOSITION

A total of 216 taxa is recorded from the coastal and estuarine environments of New Hampshire (Figures 1–5), including 58 Chlorophyceae, 66 Phaeophyceae and 92 Rhodophyceae (Tables I–III). Two of these 216 taxa (*Hecatonema terminalis* and *Myrionema magnusii*) were not collected by us, but they were recorded by Collins (1900) from the state with no specific dates nor collection sites. All of the other taxa, except for *Acrochaete repens, Bolbocoleon piliferum, Prasinocladus marinus* and *Sphaerotrichia divaricata,* which were only obtained in culture after their grow-out in enriched sea water media (Zechman and Mathieson, 1985), were collected in one or more estuarine and/or open coastal habitats. Eight of the 216 taxa recorded herein are new records for the state, including one brown (*Sphaerotrichia divaricata*) and seven red algae (*Audouinella violaceae, Callocolax neglectus, Ceramium elegans, Cruoriopsis ensis, Halosacciocolax kjellmanii, "Porphyrodiscus simulans"* and *Turnerella pennyi*). [*Porphyrodiscus simulans* and its other life history stages (cf. Farnham and Fletcher, 1976) are hereafter designated by quotes.] Each of the seven red algae represents either a range extension or a new record for the northeastern coast of North America. For example, the "fresh water" red alga *Audouinella violacea* is newly recorded from coastal waters of the northeast; it grows as an epiphyte on the fresh water red alga *Sacheria fucina,* and it may occur abundantly within riverine habitats. The specific parasite *Callocolax neglectus* which grows abundantly on *Callophyllis cristata,* was previously recorded from Greenland (Pedersen, 1976) and Newfoundland (South and Hooper, 1980). *Ceramium elegans* was earlier known from the Canadian Maritime Provinces (South, 1984; Taylor, 1957), while *Halosacciocolax kjellmanii* and *"Porphyrodiscus simulans"* were recorded from Newfoundland and the Canadian Maritime Provinces (South, 1984). The geographical distribution of *Turnerella pennyi* was previously recorded from the Arctic to the Atlantic coast of Nova Scotia, while Taylor (1957) only listed *"Cruoriopsis ensis"* from southern Massachusetts. The green alga *Codium fragile* ssp. *tomentosoides* has recently (1983) been found attached at Appledore Island, Maine, Isles of Shoals (Figure 2), and it could extend to adjacent New Hampshire sites (Carlton and Scanlon, 1985; Mathieson and Penniman, 1986a).

PHENOLOGY AND LONGEVITY

A summary of the temporal variation of seaweed taxa within estuarine-coastal waters of New Hampshire is given in Figure 13, based upon the data in Tables I–III. The number of taxa/month was highest in August (178) and lowest in January (105). Each of the three major groups of seaweeds showed a similar seasonal pattern, except that the Chlorophyceae had their highest number of taxa in July (42). Similar phenological patterns with summer maxima and winter minima have been noted in several other North Atlantic areas (Coleman and Mathieson, 1975; Lamb and Zimmerman, 1964; MacFarlane and Bell, 1933; Reynolds and Mathieson, 1975; Sears and Wilce, 1975). Chapman (1964) and Williams (1948, 1949) have emphasized that seasonally dynamic floras and a wide range of

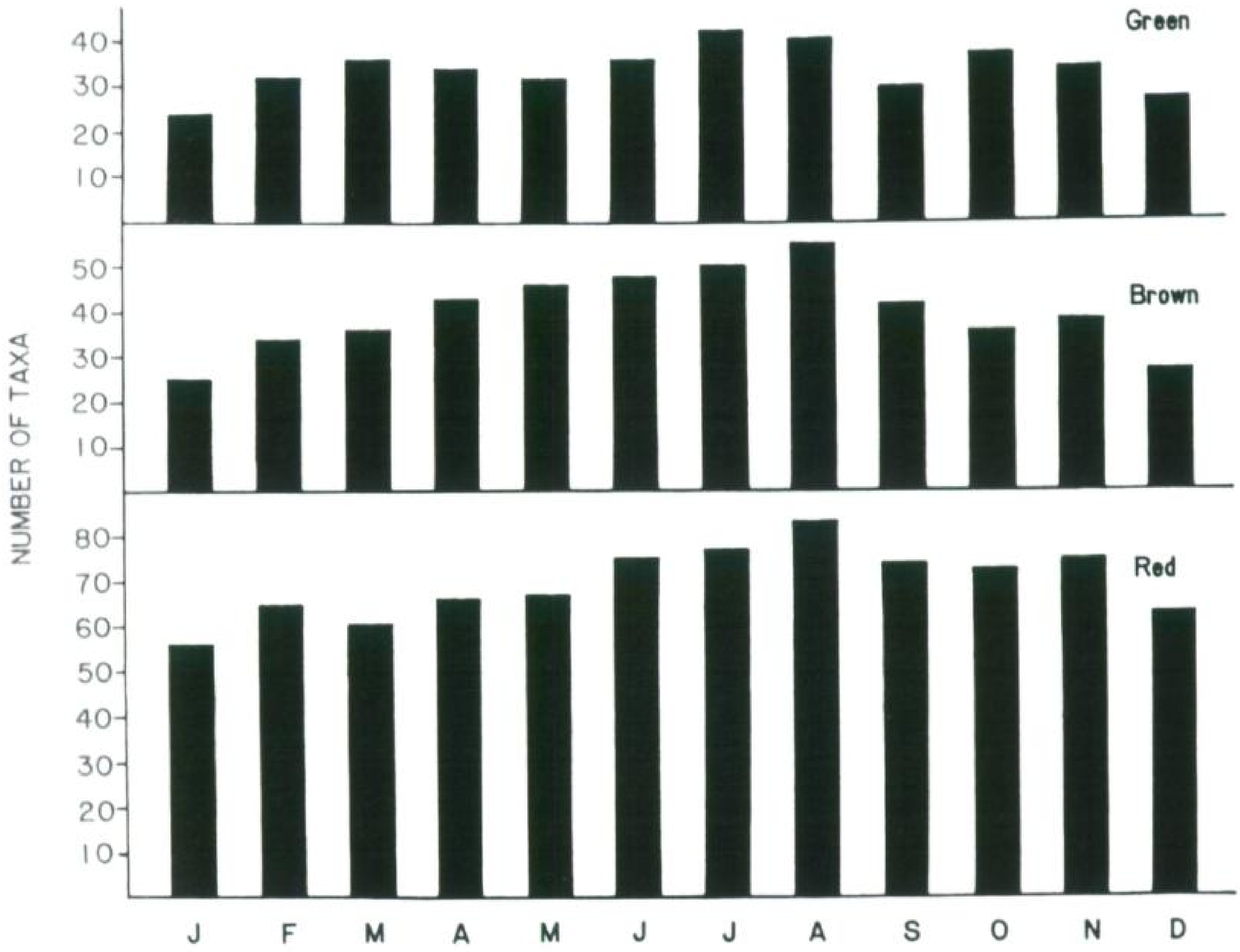

Figure 13. Temporal variations of seaweed taxa within estuarine-coastal waters of New Hampshire, expressed as the number of taxa/month.

annuals exist in areas with pronounced temperature fluctuations. The functional role of annuals in mediating the seasonal cycle of New Hampshire seaweeds is shown in Tables I–III.

Of the total algal flora outlined in Tables I–III, 113 taxa (52.3%) were designated as annuals and 100 taxa (46.3%) were interpreted as perennials (Figure 14). Three algae (*Cladophora sericea, Derbesia marina* and *Ulva lactuca*) or 1.4% of the flora, require further study as they may be either aseasonal annuals or pseudoperennials (*sensu* Knight and Parke, 1931). As outlined below, the longevity patterns (ratios of annuals/perennials and the percentage of perennial taxa) for the three major groups of seaweeds are conspicuously different:

1. Rhodophyceae—30 annuals/62 perennials (0.48:1) or 67.4% perennials

2. Phaeophyceae—36 annuals/30 perennials (1.2:1) or 45.5% perennials

3. Chlorophyceae—47 annuals/8 perennials (5.9:1) or 13.8% perennials

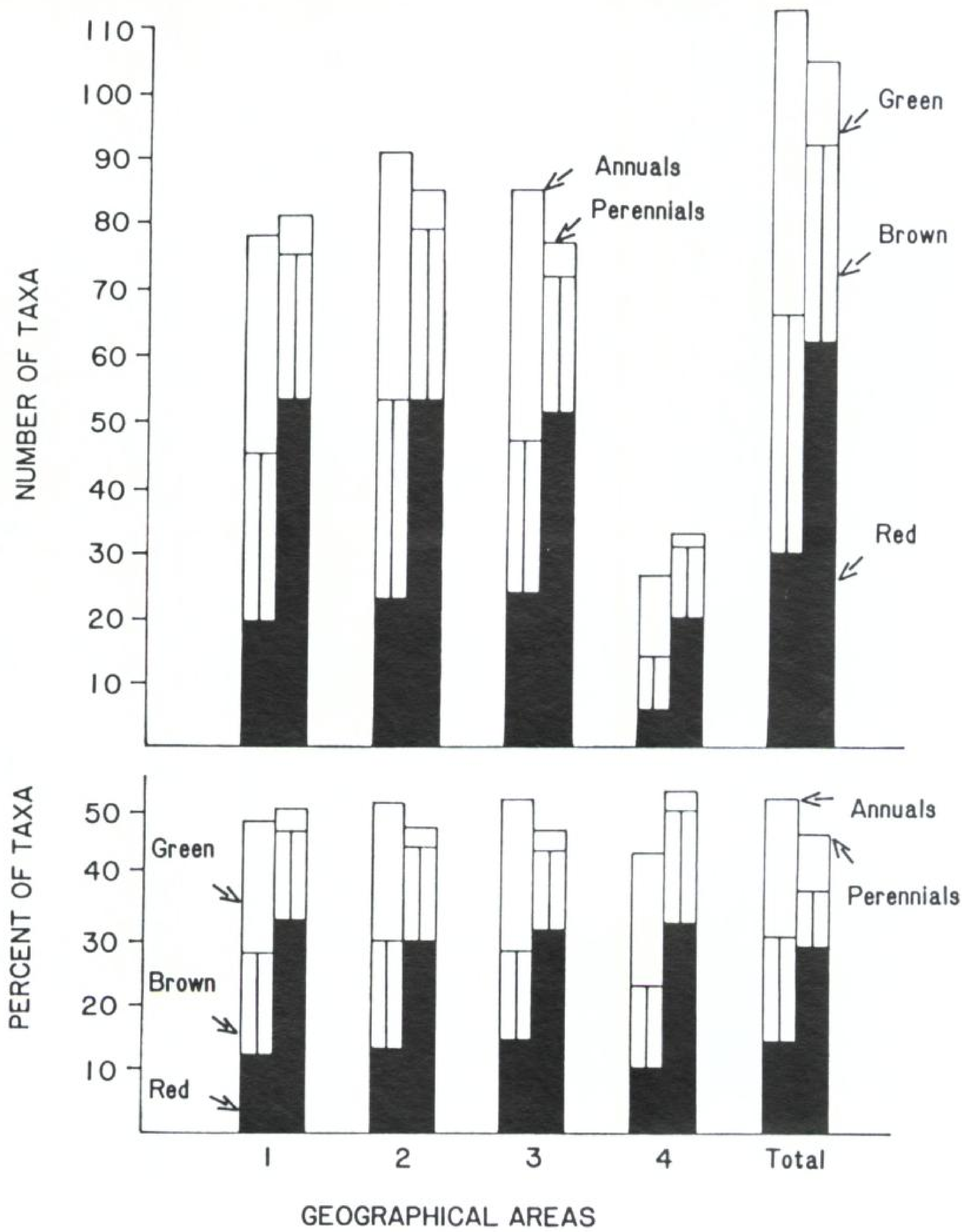

Figure 14. The number and percentage of annual and perennial chlorophycean, phaeophycean and rhodophycean taxa within estuarine-coastal waters of New Hampshire.

Thus, the red algae exhibit the greatest dominance by perennials, the brown algae have an intermediate pattern and the green algae exhibit the greatest dominance by annuals.

As outlined in Tables I–III, three distinct types of seasonal annuals (winter, spring and summer) plus aseasonal annuals can be distinguished, according to their season of maximum growth and development. No fall annuals were found, although many summer plants persist into fall and early winter. Thus, the fall season appears to be a transition period between summer and winter floras. Most of the seasonal annuals reproduce during their periods of maximum abundance. On the other hand some aseasonal annuals (*Petalonia fascia* and *Scytosiphon lomentaria* var. *lomentaria*) are reproductive throughout the year while others such as *Dumontia contorta* only reproduce during more restricted periods (Hehre and Mathieson, 1970; Kilar and Mathieson, 1978; Mathieson and Hehre, 1982, 1983). Similarly, these authors as well as Tveter-Gallagher et al. (1980), pointed out that many perennials are reproductive throughout the year, while others exhibit distinct reproductive periods.

Several taxa were only collected *in situ* a few times (*Chlorochytrium moorei, "Halicystis ovalis," Pringsheimiella scutata, Spirogyra* sp., *Stichococcus marinus, Stigeoclonium* sp., *Cladostephus spongiosus* forma *verticillatus, Eudesme virescens, Giffordia secunda, Scytosiphon lomentaria* var. *complanatus, Sorocarpus micromorus, Sphacelaria fusca, Audouinella polyides, Ceramium elegans, Colaconema polyides, "Cruoriopsis ensis," Erythropeltis discigera* var. *discigera, Halosacciocolax kjellmanii, "Porphyrodiscus simulans,"* and *Turnerella pennyi*). Several of these plants plus *Acrochaete repens, Bolbocoleon piliferum, Prasinocladus marinus* and *Sphaerotrichia divaricata,* which were only found in culture (Tables I–III), may have been missed due to their small stature. In contrast to these "rare" taxa, many of the larger perennial forms were ubiquitous at a wide variety of coastal and estuarine sites throughout the year. Specific details on the seasonal occurrence and longevity of each taxon are summarized in Tables I–III.

PATTERNS OF LOCAL DISTRIBUTION

A summary of the local distribution of the chlorophycean, phaeophycean and rhodophycean taxa in the four major coastal-estuarine areas in New Hampshire is shown in Figure 15. The highest number of taxa (179) was recorded from the nearshore open coast between Portsmouth and Seabrook. The species richness at the Isles of Shoals and within the Great Bay Estuary System was

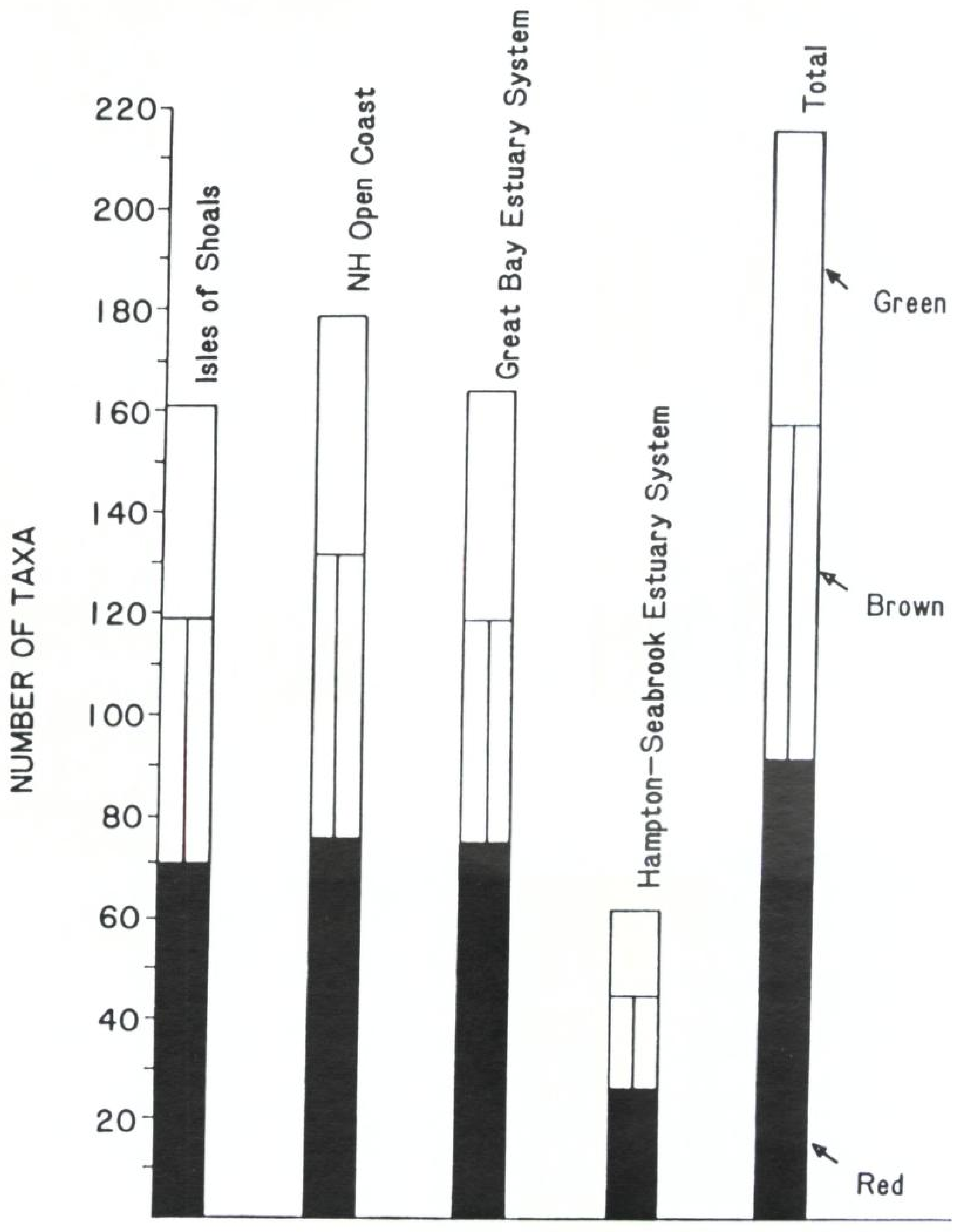

Figure 15. Local distribution of chlorophycean, phaeophycean and rhodophycean taxa within the four major coastal-estuarine areas in New Hampshire.

nearly the same (161 and 164 taxa, respectively), although the species composition of each was conspicuously different. The low species richness (63 taxa) within the Hampton-Seabrook Estuary System contrasts strongly with that of the Great Bay Estuary. Each of the three major groups of seaweeds exhibited their minimum number of species within the Hampton-Seabrook Estuary System. The Chloropyceae and Rhodophyceae had an approximate equality of species numbers at the two open coastal areas and within the Great Bay Estuary System, with 42–47 green algal taxa at the three habitats versus 71–76 red algae at the same three sites. In contrast, the Phaeophyceae exhibited a more pronounced difference between the nearshore open coast and the Great Bay Estuary System, with 56 taxa at the former and 44 taxa at the latter.

As noted by Mathieson and Fralick (1972), the low species richness within the Hampton-Seabrook Estuary may be associated with its limited acreage (reduced habitats) and lack of stable substrata. On the other hand, the relatively high species diversity at the Isles of Shoals (comparable to the nearshore open coast and the entire Great Bay Estuary System), is impressive as they are a small albeit relatively "pristine" set of islands (Mathieson and Penniman, 1986a).

The species composition within the Great Bay Estuary System is very different than that at the Shoals and the nearshore open coast, because of the presence of several freshwater algae, the enhanced number of "estuarine" taxa and the reduced number of "coastal" species. A similar reduction of open coastal species within estuarine habitats has been related to variable hydrographic conditions and limited rocky substrata (Doty and Newhouse, 1954; Hardwick-Witman and Mathieson, 1983; Mathieson and Fralick, 1972; Mathieson, Reynolds and Hehre, 1981).

The coastal and/or estuarine distributional patterns of each chlorophycean, phaeophycean and rhodophycean taxon are summarized in Tables I–III, as well as within the individual distribution maps (Figures 16–229). Overall, three basic patterns are evident as follows:

1. coastal—restricted to the open coast
2. cosmopolitan—present in both estuarine and open coastal environments
3. estuarine—restricted to estuarine environments

Approximately 23% of the total flora (49 of 216 taxa) were restricted to the open coast. Twenty-five of these taxa occurred in both open coastal habitats (Figures: 30. *Cladophora rupestris;* 33. *"Codiolum petrocelidis";* 36. *Derbesia marina;* 45. *Entocladia flus-*

trae; 47. *Gomontia polyrhiza;* 75. *Alaria esculenta;* 76. *Ascocyclus distromaticus;* 79. *Asperococcus fistulosus;* 106. *Laminariocolax tomentosoides;* 107. *Leathesia difformis;* 108. *Mikrosyphar porphyrae;* 115. *Protectocarpus speciosus;* 118. *Punctaria plantaginea;* 123. *Saccorhiza dermatodea;* 141. *Audouinella alariae;* 158. *Ceratocolax hartzii;* 168. *Devaleraea ramentaceum;* 170. *Erythropeltis discigera* var. *discigera;* 179. *Harveyella mirabilis;* 181. *Leptophytum foecundum;* 189. *Nemalion helminthoides;* 196. *Phyllophora traillii;* 200. *Phymatolithon rugulosum;* 210. *Polysiphonia novae-angliae;* 227. *Spermothamnion repens*). On the other hand, nine taxa were restricted to the Isles of Shoals (Figures: 25. *Chaetomorpha minima;* 35. *Codium fragile* subsp. *tomentosoides;* 58. *Pringsheimiella scutata;* 65. *Stichococcus marinus;* 83. *Cladostephus spongiosus* forma *verticillatus;* 93. *Fucus distichus* subsp. *anceps;* 130. *Sphacelaria fusca;* 178. *Halosacciocolax kjellmanii;* 191. *Pantoneura baeri*), while 13 were only collected from the nearshore open coast (Figures: 18. *Bolbocoleon piliferum;* 27. *Chlorochytrium moorei;* 48. *"Halicystis ovalis";* 56. *Prasinocladus marinus;* 92. *Eudesme virescens;* 101. *Giffordia secunda;* 128. *Sphacelaria arctica;* 131. *S. plumigera;* 132. *S. plumosa;* 134. *Sphaerotrichia divaricata;* 143. *Audouinella polyides;* 218. *Porphyropsis coccinea;* 229. *Turnerella pennyi*).

In contrast to the moderate number of open coastal taxa, 145 species or 67% of the total flora exhibited a cosmopolitan distribution, occurring in both open coastal and estuarine habitats. Several of these cosmopolitan species were broadly distributed in estuarine habitats (Figures: 17. *Blidingia minima;* 23. *Chaetomorpha linum;* 31. *Cladophora sericea;* 37, 38, 40, 41, 42 & 43. *Enteromorpha* ssp.; 51. *Monostroma grevillei;* 55. *Percursaria percursa;* 60. *Rhizoclonium riparium;* 67. *Ulothrix flacca;* 69. *Ulva lactuca;* 70. *Ulvaria obscura;* 77. *Ascophyllum nodosum;* 90. *Ectocarpus siliculosus;* 96. *Fucus distichus* subsp. *evanescens;* 98. *F. vesiculosus;* 111. *Petalonia fascia;* 114. *Pilayella littoralis;* 122. *Ralfsia verrucosa;* 125. *Scytosiphon lomentaria* var. *lomentaria;* 138. *Ahnfeltia plicata;* 151. *Callithamnion tetragonum;* 156. *Ceramium rubrum;* 160. *Chondrus crispus;* 165. *Cystoclonium purpureum;* 169. *Dumontia contorta;* 177. *Gymnogongrus crenulatus;* 180. *Hildenbrandia rubra;* 195. *Phyllophora pseudoceranoides;* 197. *P. truncata;* 202. *Polyides rotundus;* 205. *Polysiphonia flexicaulis;* 206. *P. harveyi;* 208. *P. nigra;* 209. *P. nigrescens;* 216. *Porphyra umbilicalis*). Many other cosmopolitan species were restricted to outer estuarine sites, that is, adjacent to the open coast, or they occurred as "disjunct" populations within estuarine tidal rapid sites such as Dover Point and Fox Point (Figures: 21. *Chaetomorpha aerea;* 24. *C. melagonium;* 34. *"Codiolum pusillum";* 52. *Monostroma pulchrum;* 57. *Prasiola stipitata;* 59. *Pseudendoclonium submarinum;* 73. *Urospora wormskioldii;* 74. *Agarum cribrosum;* 80. *Chorda filum;* 81. *C. tomentosa;* 85. *Desmarestia aculeata;* 86. *D. viridis;* 87. *Desmotrichum undulatum;* 88. *Dictyosiphon foeniculaceus;* 89. *Ectocarpus fasciculatus;* 91. *Elachista fucicola;* 94. *Fucus distichus* subsp. *distichus;* 95. *F. distichus* subsp. *edentatus;* 103. *Laminaria digitata;* 104. *L. longicruris;* 109. *Myrionema corunnae;* 112. *Petalonia zosterifolia;* 121. *Ralfsia fungiformis;* 135. *Spongonema tomentosum;* 137. *Ulonema rhizophorum;* 144. *Audouinella purpurea;* 152. *Callocolax neglectus;* 153. *Callophyllis cristata;* 161. *Choreocolax polysiphoniae;* 163. *Corallina officinalis;* 167. *Dermatolithon pustulatum;* 173. *Gigartina stellata;* 174. *Gloiosiphonia capillaris;* 182. *Leptophytum laeve;* 183. *Lithophyllum corallinae;* 184. *Lithothamnion glaciale;* 187. *Lomentaria orcadensis;* 188. *Membranoptera alata;* 192. *"Petrocelis cruenta";* 194. *Phycodrys rubens;* 198. *Phymatolithon laevigatum;* 199. *P. lenormandii;* 201. *Plumaria elegans;* 207. *Polysiphonia lanosa;* 212. *P. urceolata;* 213. *Porphyra leucosticta;* 220. *Ptilota serrata;* 221. *Rhodomela confervoides;* 222. *Rhodophyllis dichotoma;* 228. *"Trailliella intricata"*). A few cosmopolitan taxa were uncommon/rare on the open coast but widely distributed in estuarine habitats (Figures: 19. *Bryopsis plumosa;* 20. *Capsosiphon fulvescens;* 44. *Enteromorpha torta;* 49. *Kornmannia leptoderma;* 50. *Microspora pachyderma;* 71. *Ulvaria oxyspermum;* 139. *Antithamnion cruciatum;* 157. *Ceramium strictum;* 159. *Chondria baileyana;* 175. *Goniotrichum alsidii;* 186. *Lomentaria clavellosa* (only collected once on the open coast at Boone Island, Maine); 204. *Polysiphonia elongata*).

Sixteen seaweeds or 7% of the total flora were restricted to the Great Bay and/or Hampton-Seabrook Estuary Systems (Figures: 29. *Cladophora pygmaea;* 39. *Enteromorpha flexuosa* subsp. *flexuosa;* 78. *Ascophyllum nodosum* ecad. *scorpioides;* 117. *Punctaria latifolia;* 124. *Scytosiphon lomentaria* var. *complanatus;* 127. *Sorocarpus micromorus;* 136. *Stictyosiphon griffithsianus;* 149. *Callithamnion byssoides;* 155. *Ceramium elegans;* 166. *Dasya baillouvi-*

ana; 176. *Gracilaria tikvahiae;* 185. *Lomentaria baileyana;* 203. *Polysiphonia denudata;* 211. *P. subtilissima;* 217. *"Porphyrodiscus simulans"*; 224. *Rhodophysema georgii*). Six "fresh-water" taxa were found attached in riverine habitats near the headwaters of tidal tributaries (Figures: 53. *Mougeotia* sp.; 54. *Oedogonium* sp.; 62. *Spirogyra* sp.; 66. *Stigeoclonium* sp.; 146. *Audouinella violacea;* 225. *Sacheria fucina*). Some of the latter species, such as *Sacheria fucina,* are known to be tolerant of reduced salinities (Wood and Straughan, 1953).

As outlined by Mathieson, Reynolds and Hehre (1981), closely related taxa often have distinct distributional patterns within estuaries. The different taxa of *Chaetomorpha* (Figures 21–26), *Cladophora* (Figures 28–31), *Monostroma* (Figures 51, 52), *Rhizoclonium* (Figures 60, 61), *Ulvaria* (Figures 70, 71), *Ectocarpus* (Figures 89, 90), *Fucus* (Figures 93–98), *Laminaria* (Figures 103–105), *Punctaria* (Figures 117, 118), *Ralfsia* (Figures 119–122), *Sphacelaria* (Figures 128–133), *Audouinella* (Figures 141–146), *Callithamnion* (Figures 149–151), *Ceramium* (Figures 154–157), *Lomentaria* (Figures 185–187), *Phyllophora* (Figures 195–197), *Phymatolithon* (Figures 198–200), *Polysiphonia* (Figures 203–212) and *Porphyra* (Figures 213–216) can all be cited. For example, of the six *Chaetomorpha* species recorded (Table I, Figures 21–26), one (*C. minima*) was restricted to the Isles of Shoals, while five (*C. aerea, C. brachygona, C. linum, C. melagonium* and *C. picquotiana*) exhibited cosmopolitan distributional patterns of varying degrees. Overall, *C. linum* was the most ubiquitous and broadly distributed species (Figure 23). The different taxa of *Fucus* exhibited a similar pattern (Tables I and II, Figures 93–98), with one taxon (*F. distichus* subsp. *anceps*) being restricted to the Isles of Shoals, and five (*F. distichus* subsp. *distichus, F.d.* subsp. *edentatus, F.d.* subsp. *evanescens, F. spiralis* and *F. vesiculosus*) exhibiting varying cosmopolitan distributional patterns. *Fucus vesiculosus* was the most broadly distributed taxon of this group (Figure 98). A comparison of the ten *Polysiphonia* species (Table III, Figures 203–212) shows that two species (*P. denudata* and *P. subtilissima*) were restricted to estuarine environments, one (*P. elongata*) was rare on the open coast, six (*P. flexicaulis, P. harveyi, P. lanosa, P. nigra, P. nigrescens* and *P. urceolata*) exhibited cosmopolitan distributions, and one (*P. novae-angliae*) was restricted to the open coast. Similar distributional comparisons can also be made for different genera in the same families (*sensu* Smith, 1950; South, 1984): Ulotrichaceae (*Stichococcus* and *Ulothrix,* Figures 65, 67 and 68); Chaetophoraceae (*Acrochaete, Bolbocoleon, Entocladia, Pringsheimiella, Pseudendoclonium* and *Stigeoclonium,* Figures 16, 18, 45, 46, 58, 59 and 66); Acrosiphoniaceae (*Spongomorpha* and *Urospora,* Figures 63, 64, 72 and 73); Percursariaceae (*Blidingia, Gomontia, Kornmannia, Monostroma* and *Percursaria,* Figures 17, 47, 49, 51, 52 and 55); Ulvaceae (*Capsosiphon, Enteromorpha, Ulva* and *Ulvaria,* Figures 20, 37–44, 69, 70 and 71); Cladophoraceae (*Chaetomorpha, Cladophora* and *Rhizoclonium,* Figures 21–26, 28–31, 60 and 61); Bryopsidaceae (*Bryopsis* and *Derbesia,* Figures 19 and 36); Zygnemataceae (*Mougeotia* and *Spirogyra,* Figures 53 and 62); Ectocarpaceae (*Ectocarpus, Giffordia, Laminariocolax, Mikrosyphar, Pilayella, Sorocarpus* and *Spongonema,* Figures 89, 90, 99–101, 106, 108, 114, 127 and 135); Ralfsiaceae (*Petroderma, Pseudolithoderma, Ralfsia fungiformis, R. verrucosa* and *Sorapion,* Figures 113, 116, 121, 122 and 126); Myrionemataceae (*Ascocyclus, Myrionema, Protectocarpus* and *Ulonema,* Figures 76, 109, 110, 115 and 137); Chordariaceae (*Chordaria, Eudesme* and *Sphaerotrichia,* Figures 82, 92 and 134); Striariaceae (*Isthmoplea* and *Stictyosiphon,* Figures 102 and 136); Punctariaceae (*Asperococcus, Desmotrichum* and *Punctaria,* Figures 79, 87, 117 and 118); Scytosiphonaceae (*Petalonia* and *Scytosiphon,* Figures 111, 112, 124 and 125); Laminariaceae (*Agarum, Laminaria* and *Saccorhiza,* Figures 74, 103–105 and 123); Fucaceae (*Ascophyllum* and *Fucus,* Figures 77, 78 and 93–98); Cystocloniaceae (*Cystoclonium* and *Rhodophyllis,* Figures 165 and 222); Phyllophoraceae (*Ahnfeltia, Ceratocolax, Gymnogongrus* and *Phyllophora,* Figures 138, 158, 177 and 195–197); Gigartinaceae (*Chondrus* and *Gigartina,* Figures 160 and 173); Corallinaceae (*Clathromorphum, Corallina, Dermatolithon, Fosliella, Leptophytum, Lithophyllum, Lithothamnion* and *Phymatolithon,* Figures 162, 163, 167, 172, 181–184 and 198–200); Kallymeniaceae (*Callocolax* and *Callophyllis,* Figures 152 and 153); Choreocolaceae (*Choreocolax* and *Harveyella,* Figures 161, 179); Palmariaceae (*Devaleraea, Halosacciocolax, Palmaria* and *Rhodophysema,* Figures 168, 178, 190, 223 and 224); Ceramiaceae (*Antithamnion, Antithamnionella, Callithamnion, Ceramium, Plumaria, Pterothamnion, Ptilota, Scagelia* and *Spermothamnion,* Figures 139, 140, 149–151, 154–157, 201, 219, 220, 226 and 227);

Delesseriaceae (*Membranoptera, Pantoneura* and *Phycodrys,* Figures 188, 191 and 194); Rhodomelaceae (*Chondria, Polysiphonia* and *Rhodomela,* Figures 159, 203–212 and 221); Erythropeltidaceae (*Erythropeltis, Erythrotrichia* and *Porphyropsis,* Figures 170, 171 and 218); Bangiaceae (*Bangia* and *Porphyra,* Figures 147 and 213–216). The members of the Gigartinaceae can be cited as specific examples (Figures 160 and 173); both *Chondrus* and *Gigartina* exhibit cosmopolitan distribution patterns, although *G. stellata* has the most restricted outer estuarine pattern and a conspicuous reduction of stature in estuarine habitats (Burns and Mathieson, 1972b).

Based upon the data in Tables I–III plus previous floristic studies (Hehre and Mathieson, 1970; Mathieson and Hehre, 1982, 1983), it is apparent that several endophytic, epiphytic and parasitic seaweeds and their respective "hosts" demonstrate contrasting distributional patterns. The following taxa can be cited as examples:

1. endophytic *Mikrosyphar porphyrae* growing in various *Porphyra* species, particularly *P. umbilicalis* (Figures 108, 213–216)
2. epiphytic *Ascocyclus distromaticus* growing on *Palmaria palmata* (Figures 76, 190); *Elachista fucicola* on *Ascophyllum nodosum* (Figures 77, 91); *Laminariocolax tomentosoides* and *Myrionema corunnae* on various *Laminaria* species (Figures 103–106, 109); *Protectocarpus speciosus* on *Chaetomorpha aerea* (Figures 21, 115); *Ulonema rhizophorum* on *Dumontia contorta* (Figures 137, 169); *Audouinella alariae* on *Alaria esculenta* (Figures 75, 141); and *A. violacea* on *Sacheria fucina* (Figures 146, 225)
3. parasitic *Callocolax neglectus* growing on *Callophyllis cristata* (Figures 152, 153); *Ceratocolax hartzii* on *Phyllophora truncata* (Figures 158, 197); *Choreocolax polysiphoniae* on *Polysiphonia lanosa* (Figures 161, 207); *Halosacciocolax kjellmani* on *Palmaria palmata* (Figures 178, 190); *Harveyella mirabilis* on *Rhodomela confervoides* (Figures 179, 221); and *Polysiphonia lanosa* on *Ascophyllum nodosum* (Figures 77, 207).

Polysiphonia lanosa (Figures 77, 207), *Laminariocolax tomentosoides* (Figures 103–106) and *Choreocolax polysiphoniae* (Figures 161, 207) are representative of the above-described species, except for *Audouinella alariae* (Figures 75, 141) and *A. violacea* (Figures 146, 225). That is, the hemiparasite *P. lanosa,* which grows abundantly on *A. nodosum* on the open coast, is restricted to outer estuarine sites, even though its host is abundant and widely distributed (Fralick and Mathieson, 1975). The common epiphyte *L. tomentosoides* and the specific parasite *C. polysiphoniae* show a similar restricted estuarine distribution versus their hosts. *Audouinella alariae* and *A. violacea* were the only species with approximately the same distribution patterns as their hosts *Alaria esculenta* and *Sacheria fucina,* respectively.

As noted by Dixon (1965), a comparison of the distributional patterns of life history stages of individual taxa can be quite informative. Deviations from a "theoretical" life history can occur geographically due to perennation and various selective mechanisms operating against a particular genome (Mathieson and Burns, 1975; Mathieson and Norall, 1975a, b; Norall et al., 1981). Dixon (1965) described the example of gametophytic *Asparagopsis armata* and tetrasporic *Falkenbergia rufolanosa,* which may exhibit independent vegetative propagation and deviations from their "theoretical" life histories at northern latitudes. The recently recorded differences in geographical distribution in Europe for the two phases (Conway, 1960; Thomas, 1955) may be a reflection of independent vegetative propagation. In comparing the coastal and/or estuarine distribution patterns of different life history phases of New England seaweeds (Tables I–III), several geographical contrasts are evident, perhaps due to the strong environmental gradient within these areas (see earlier description), the different physiological tolerances of various phases (Mathieson and Burns, 1975; Mathieson and Norall, 1975a, b; Norall et al., 1981), the different modes and magnitude of vegetative propagation, and other factors. For example, the "*Codiolum gregarium/pusillum*" sporophytic stages of *Urospora* and *Ulothrix* spp. (Kornmann and Sahling, 1977; Scagel, 1966; South, 1984) have a more localized estuarine distribution than their corresponding gametophytic phases (Figures 32, 34, 67, 72, 73). A similar trend is evident in Figures 33 and 64 for the endophytic "*Codiolum petrocelidis*" sporophyte of *Spongomorpha spinescens* (Jonsson, 1958; Scagel, 1966). Both gametophytic "*Halicystis ovalis*" and sporophytic *Derbesia marina* (Sears and Wilce, 1970) are restricted to the open coast, with the former being rare and the latter more common (Figures 36, 48). The crustose sporophytic "*Ralfsia bornetii/clavata*" and foliose gametophytic stages of *Petalonia fascia* (Edelstein et al.,

1970) both exhibit cosmopolitan distributional patterns, although the foliose stage is more widely distributed than the crustose phase (Figures 111, 119, 120). Similarly, the crustose tetrasporophyte "*Porphyrodiscus simulans*" of *Ahnfeltia plicata* (Farnham and Fletcher, 1976) was only found at one estuarine site, while the gametophytic phase was collected at diverse open coastal and estuarine habitats (Figures 138, 217). The sporophytic "*Trailliella intricata*" phase of *Bonnemaisonia hamifera* (Chihara, 1961, 1962), also exhibits a more localized distribution than its gametophytic phase (Figures 148, 228). Lastly, the crustose sporophytic "*Petrocelis cruenta*" and upright gametophytic phases of *Gigartina stellata* (Fletcher and Irvine, 1982; Guiry and Coleman, 1982; West and Polanshek, 1975; West et al., 1977) both extend from the open coast into the outer-mid portions of the Great Bay Estuary System (Figures 173, 192).

Several unique ecological or phenotypic patterns were also evident. For example, the perennial psammophytic "sand-loving" (Mathieson, 1982b) brown alga *Sphacelaria radicans* was restricted to a few sand-abraded open coastal (Daly and Mathieson, 1977) and sandy outer estuarine habitats (Figure 133). Further, attached populations of *Ascophyllum nodosum* were collected abundantly at diverse open coastal and estuarine sites (Figure 77), while the ecad *scorpioides* was restricted to sheltered estuarine sites (Figure 78), entangled amongst *Spartina alterniflora* (Chock and Mathieson, 1976). Two examples of phenotypic plasticity should also be noted. The fucoid brown alga *Fucus vesiculosus* primarily exhibits a spiraled morphology (var. *spiralis* in Taylor, 1957) in estuarine habitats, while the typical non-spiraled plant is most abundant in open coastal habitats, particularly exposed sites. Locally, most populations of *Cystoclonium purpureum* have tendril-like branches (var. *cirrhosum* in Taylor, 1957); even so, some estuarine plants exhibit radiating burr-like branches (forma *stellatum*, Collins, 1906b), which Taylor (1957) suggested are a pathological state. Although South (1984) and others suggested that subspecific taxa of *C. purpureum* are insufficiently distinct to warrant retention, the "stellatum-type" morphology seems to be restricted to sheltered estuarine sites.

In comparing the local distribution of plants based upon culture and *in situ* collections (Tables I–III), several interesting contrasts can be made. As noted earlier, four taxa were only recorded in culture (*Acrochaete repens, Bolbocoleon piliferum, Prasinocladus marinus* and *Sphaerotrichia divaricata,* Figures 16, 18, 56, 134), while the local distributional records of an additional four taxa ("*Codiolum pusillum,*" *Microspora pachyderma, Desmotrichum undulatum* and *Isthmoplea sphaerophora,* Figures 34, 50, 87, 102) were supplemented by culture information. Thus, the single estuarine record of "*C. pusillum*" was based upon culture findings, while similar statements can be made about the solitary nearshore open coastal records for *M. pachyderma, D. undulatum* and *I. sphaerophora.* Presumably these culture records are based upon the plants being rare in nature, cryptic in size, and juvenile and adult stages having different physiological tolerances/optima, or other factors. In this context, Mathieson and Hehre (1983) noted that attached populations of freshwater algae like *M. pachyderma* are typically restricted to inner estuarine/riverine habitats. Even so, juvenile (cultured) populations of *M. pachyderma* exhibit a wide tolerance to salinity, which suggests that other biological factors may restrict the plant's growth *in situ* (Zechman and Mathieson, 1985). Several unique culture records for *Enteromorpha compressa, Spongomorpha arcta, Ulvaria oxysperma, Urospora wormskioldii, Desmotrichum undulatum* and *Porphyropsis coccinea* should also be noted (Figures 38, 63, 71, 73, 87, 218). For example, the ubiquitous "estuarine" alga *U. oxysperma* was only found at four open coastal locations, one of which was based upon its presence in culture (Figure 71).

PHYSIOLOGICAL ECOLOGY AND DISTRIBUTIONAL PATTERNS OF SELECT SEAWEEDS

Several estuarine taxa, or seaweeds that are rare on the open coast of New Hampshire, represent disjunct populations north of Cape Cod, Massachusetts, on the northeast coast of North America: *Bryopsis plumosa* (Figure 19); *Ulvaria oxysperma* (Figure 71); *Antithamnion cruciatum* (Figure 139); *Ceramium strictum* (Figure 157); *Chondria baileyana* (Figure 159); *Dasya baillouviana* (Figure 166); *Gracilaria tikvahiae* (Figure 176); *Lomentaria baileyana* (Figure 185); *Polysiphonia denudata* (Figure 203); and *P. subtilissima* (Figure 211). These "southerly" taxa are more widely distributed south than north of Cape Cod and several of them extend to the tropics, Bermuda, Florida, etc. (Taylor, 1957, 1960). At their northern distributional limits, each of these plants occurs primarily in shallow embayments or protected habitats such as the Great Bay Estuary System or Northumberland Straits near Prince Edward Island, New Brunswick, Canada. All of these species, except for *G. tikvahiae*, are summer annuals (Tables I and III) at their northern limits, and they may have "modified" life histories (Mathieson and Burns, 1975; Norall et al., 1981) and extensive vegetative reproduction. As noted earlier, the hydrographic conditions within such northern latitudes are much more variable than within the central portion of the plant's geographical range. Thus, the phenologies of such "southerly" species are often conspicuously different in northern than in southern geographies (Hehre and Mathieson, 1970; Mathieson and Dawes, 1975).

Bousfield and Thomas (1975) have recorded similar disjunct patterns for many shallow water marine animals between Cape Cod, the northern Gulf of Maine and/or the Gulf of St. Lawrence. Many animal populations having similar temperature requirements are isolated from each other by hundreds of miles of climatically "unfavorable" marine coastlines, particularly during the reproductive period that is critical to natural dispersal and to maintenance of homogenous populations. The same authors speculated that the most satisfactory explanation of this distribution is an historical one; during a "hypsithermal" or warm period 7500–9500 years ago, the relatively shallow shelf waters between Cape Cod and the Gulf of St. Lawrence provided a uniform summer-warm environment and dispersal pathway. Subsequent drowning and deeping of the inshore coastal areas and increased upwelling in the Gulf of Maine during the past 5000 years have depressed the summer temperatures to present-day cool levels. In "post-hypsithermal" times the warm water fauna gradually disappeared from the cooling open coastal areas, and populations like those in the Gulf of St. Lawrence became regionally restricted and effectively isolated from the main populations in southern New England and further south. McAlice (1981) has given a similar explanation for the post-glacial history of the copepod *Acartia tonsa* in the Gulf of Maine and the Gulf of St. Lawrence. He suggested that the northern populations of this copepod, which occur in warm estuarine headwaters north of Cape Cod, are relict ones, derived from a distribution that was once continuous from Cape Cod to the Northumberland Strait (New Brunswick–Prince Edward Island). He further suggested that the disjunction of *A. tonsa* at its present refuges may make it useful for studies on rates of speciation.

The ideas presented by Bousfield and Thomsa (1975) and McAlice (1981) with respect to disjunct animal distributions would appear to be applicable to seaweeds as well. With the advent of cooling coastal waters, populations of some seaweeds may have been forced into warm estuarine habitats, while the main coastal populations receded southward. If, as McAlice (1981) suggested, these relict populations became reproductively isolated due to lower water temperatures and westerly currents, then the potential was established for genetic differentiation. The likelihood of this occurrence would be increased by differences in environmental conditions imposed upon the populations at their respective locations. Although northern estuaries provide warm summer temperatures required for the growth of "southerly" species, these estuarine populations must tolerate reduced and/or fluctuating salinities and extremely cold winter conditions. For example, the red alga *Polysiphonia subtilissima* is primarily restricted in New Hampshire–Maine to inner riverine habitats (Figure 211) where temperatures vary from 0–26° C, and salinities from 0–22 ‰ (Norall and Mathieson, 1976). Since *P. subtilissima* grows in northern locations as a pseudoperennial, regenerating from perennating holdfast filaments (Hehre and Mathieson, 1970; Yarish and Edwards, 1982), it must tolerate this entire range of conditions. South of Cape Cod, the same species may also occur on the open coast (Mathieson and Dawes, 1975) where it is exposed to more uniform temperatures and stable, coastal salinities. Consequently, broader temperature and salinity tolerances and lower optima would be of adaptive significance in northern disjunct seaweed populations, while the same attributes would be relatively unimportant to the continuous "southerly" coastal populations.

Fralick and Mathieson (1975) and Mathieson and Burns (1971), among others, have attempted to correlate the physiological ecology and estuarine distributional patterns of several seaweeds. For example, Fralick and Mathieson (1975) compared the photosynthesis and respiration of four species of *Polysiphonia* under different light, temperature and salinity conditions and found that they could be separated into a "cold water" group (*P. lanosa* and *P. elongata*) and a group with warm-water affinities (*P. nigrescens* and *P. subtilissima*). They speculated that the horizontal distribution of these four *Polysiphonia* taxa within the Great Bay Estuary System (Figure 204, 207, 209, 211) was primarily governed by their varying tolerances to high temperatures and low salinities. Thus, *P. subtilissima,* which had the highest temperature optimum, penetrated the furthest into the estuary (Figure 211), while *P. lanosa,* which had the lowest temperature optimum, was restricted to the more coastal stations (Figure 207). Mathieson and Burns (1971) conducted a similar physiological study of the closely-related gigartinaleanm red algae *Chondrus crispus* and *Gigartina stellata.* Both species exhibited broad tolderances to salinity. Even so, *C. crispus* showed its maximum photosynthesis and minimum respiration at 24 ‰, in agreement with the more open coastal habitat of *Gigartina* and the more estuarine habitat of *Chondrus* (Figures 160, 173). Culture studies of juvenile stages (sporelings from carpospores) from both plants have demonstrated a similar restricted tolerance to reduced salinities for *G. stellata* as compared to *C. crispus* (Burns and Mathieson, 1972a). The above-described physiological and culture studies, including those of Zechman and Mathieson (1985), demonstrate the potential for experimentally evaluating the distributional patterns of diverse seaweeds (Hoek, 1982a, b).

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List of Tables

Key to Tables I–III

x = present
* = obtained in culture
** = residual basal material

Longevity: Ann. = annual
AAnn. = aseasonal annual
Per. = perennial
PPer. = pseudoperennial

Local Distribution: 1 = Isles of Shoals
2 = Nearshore open coast between Portsmouth and Seabrook
3 = Hampton-Seabrook Estuary System
4 = Great Bay Estuary System

Table I: Seasonal occurrence, longevity and local distribution of Chlorophyceae

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Acrochaete repens N. Pringsh.			X*				X*						Ann.	2*, 4*
Blidingia minima (Näg. *ex* Kütz.) Kylin	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1–4
Bolbocoleon piliferum N. Pringsh.			X*				X*						Ann.	2*
Bryopsis plumosa (Huds.) C. Ag.		X**				X	X	X	X	X	X	X	Ann.	1–4
Capsosiphon fulvescens (C. Ag.) Setch. *et* Gardn.			X*		X	X	X	X	X	X	X	X	Ann.	2, 4
Chaetomorpha aerea (Dillw.) Kütz.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Chaetomorpha brachygona Harv.	X		X		X	X	X	X	X	X	X	X	Ann. (?)	1, 2, 4
Chaetomorpha linum (O. F. Müll.) Kütz.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Chaetomorpha melagonium (Web. *et* Mohr) Kütz.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Chaetomorpha minima Collins F. *et* Herv.										X	X		Ann. (?)	1
Chaetomorpha picquotiana Mont. *ex*. Kütz.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Chlorochytrium moorei Gardn.										X			Ann.	2
Cladophora albida (Huds.) Kütz.		X	X	X		X	X	X		X		X	AAnn.	1, 2, 4
Cladophora pygmeaea Reinke	X	X	X	X	X	X	X	X	X	X			Per.	4
Cladophora rupestris (L.) Kütz.		X				X		X		X			Per.	1, 2
Cladophora sericea (Hud.) Kütz.	X	X	X	X	X	X	X	X	X	X	X	X	AAnn. or PPer.	1–4
"*Codiolum gregarium* A. Braun"							X*	X			X		Ann.	2, 4

Table I: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
"*Codiolum petrocelidis* Kuck."			X					X					Ann. (?)	1, 2
"*Codiolum pusillum* (Lyngb.) Kjellm."		X				X	X	X	X	X	X	X	Ann.	1, 2, 4*
Codium fragile (Sur.) Hariot subsp. *tomentosoides* (van Goor) Silva				X	X			X					Per.	1
Derbesia marina (Lyngb.) Solier				X	X						X		Ann. or PPer.	1, 2
Enteromorpha clathrata (Roth) Grev.				X		X	X	X	X	X	X	X	Ann.	1–4
Enteromorpha compressa (L.) Grev.	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1–4
Enteromorpha flexuosa (Wulf. *ex* Roth) J. Ag. subsp. *flexuosa* Bliding							X		X	X			Ann.	4
Enteromorpha flexuosa (Wulf. *ex* Roth) J. Ag. subsp. *paradoxa* (Dillw.) Bliding		X		X			X	X	X	X	X	X	Ann.	1–4
Enteromorpha intestinalis (L.) Link	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1–4
Enteromorpha linza (L.) J. Ag.	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1–4
Enteromorpha prolifera (O. F. Müll.) J. Ag.	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1–4
Enteromorpha torta (Mert. *in* Jürg.) Reinb.				X			X	X	X	X		X	Ann.	2, 4
Entocladia flustrae (Reinke) Batt.		X		X		X							Ann. (?)	1, 2
Entocladia viridis Reinke	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1, 2, 4
Gomontia polyrhiza (Lagerh.) Bornet *et* Flah.			X					X					Ann. (?)	1, 2

Table I: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
"*Halicystis ovalis* (Lyngb.) Aresch."							X						Per. (?)	2
Kornmannia leptoderma (Kjellm.) Bliding					X	X	X	X	X				Ann.	2, 4
Microspora pachyderma (Wille) Lagerh.	X	X	X	X	X	X*	X*			X	X*		Ann.	2*, 4
Monostroma grevillei (Thur.) Wittr.	X	X	X	X	X	X				X	X	X	Ann.	1–4
Monostroma pulchrum Farl.			X	X	X	X							Ann.	1, 2, 4
Mougeotia sp.							X						Ann.	4
Oedogonium sp.								X	X				Ann.	4
Percursaria percursa (C. Ag.) Rosenv.		X	X	X	X	X	X	X	X	X	X	X	AAnn.	1–4
Prasinocladus marinus (Cienk.) Waern							X*						Ann.	2*
Prasiola stipitata Suhr. *in* Jessen	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1, 2, 4
Pringsheimiella scutata (Reinke) Marchew.			X							X			Ann. (?)	1
Pseudendoclonium submarinum Wille							X	X			X		AAnn.	1, 4
Rhizoclonium riparium (Roth) Harv.	X	X	X	X	X	X	X	X	X	X	X		AAnn.	1–4
Rhizoclonium tortuosum (Dillw.) Kütz.	X	X	X	X	X	X	X	X	X	X	X		AAnn. (?)	1, 2, 4
Spirogyra sp.							X						Ann.	4
Spongomorpha arcta (Dillw.) Kütz.		X	X	X	X	X	X	X	X	X	X	X	Ann.	1, 2, 4
Spongomorpha spinescens Kütz.				X	X	X	X	X		X	X	X	Ann.	1, 2, 4
Stichococcus marinus (Wille) Hazen						X							Ann.	1

Table I: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Stigeoclonium sp.			X										Ann.	4
Ulothrix flacca (Dillw.) Thur. *in* Le Jolis	X	X	X	X	X	X		X			X	X	Ann.	1, 2, 4
Ulothrix speciosa (Carm. *ex* Harv. *in* Hook.) Kütz.		X	X	X	X								Ann.	1, 2, 4
Ulva lactuca L.	X	X	X	X	X	X	X	X	X	X	X	X	Ann. or PPer.	1–4
Ulvaria obscura (Kütz.) Gayral	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1–4
Ulvaria oxysperma (Kütz.) Bliding	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1–4
Urospora penicilliformis (Roth) Aresch.	X	X	X	X	X	X	X	X		X	X	X	Ann.	1, 2, 4
Urospora wormskioldii (Mert. *in* Hornem.) Rosenv.	X	X	X	X	X		X	X*				X	Ann.	1, 2, 4
Monthly total Chlorophyta taxa	24	32	36	34	33	36	42	40	30	37	34	27		

Table II: Seasonal occurrence, longevity and local distribution of Phaeophyceae

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Agarum cribrosum (Mert.) Bory	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Alaria esculenta (L.) Grev.		X	X	X	X	X	X	X	X	X	X		Per.	1, 2
Ascocyclus distromaticus Tayl.	X			X	X		X	X	X				Ann.	1, 2
Ascophyllum nodosum (L.) Le Jol.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Ascophyllum nodosum (L.) Le Jol. ecad *scorpioides* (Reinke) Hauck	X	X	X	X	X	X	X	X	X	X	X	X	Per.	3, 4
Asperococcus fistulosus (Huds.) Hook.				X		X	X	X	X				Ann.	1, 2
Chorda filum (L.) Stackh.					X	X	X	X	X		X		Ann.	1–4
Chorda tomentosa Lyngb.				X	X	X		X					Ann.	1, 2, 4
Chordaria flagelliformis (O. F. Müll.) C. Ag.	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1–4
Cladostephus spongiosus (Huds.) C. Ag. forma *verticillatus* (Lightf.) Post. et Rupr.		X											Per. (?)	1
Delamara attenuata (Kjellm.) Rosenv.				X	X	X					X		Ann.	1, 4
Desmarestia aculeata (L.) Lamour.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Desmarestia viridis (O. F. Müll.) Lamour.	X	X	X	X	X	X	X	X	X				Ann.	1, 2, 4
Desmotrichum undulatum (J. Ag.) Reinke				X	X	X*		X					Ann.	1, 2*, 4
Dictyosiphon foeniculaceus (Huds.) Grev.			X	X	X	X	X	X	X	X			Ann.	1–4
Ectocarpus fasciculatus Harv.				X	X	X	X	X	X	X			Ann.	1, 2, 4
Ectocarpus siliculosus (Dillw.) Lyngb.	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1–4

Table II: (Cont.)

	Month													Local
Taxa	J	F	M	A	M	J	J	A	S	O	N	D	Longevity	Distribution
Elachista fucicola (Vell.) Aresch.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1-4
Eudesme virescens (Carm. *ex* Harv. *in* Hook.) J. Ag.							X						Ann.	2
Fucus distichus L. subsp. *anceps* (Harv. *et* Ward *ex* Carr.) Powell	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1
Fucus distichus L. subsp. *distichus* L. emend. Powell	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Fucus distichus L. subsp. *edentatus* (Pyl.) Powell	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1-4
Fucus distichus L. subsp. *evanescens* (C. Ag.) Powell	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Fucus spiralis L.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Fucus vesiculosus L.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1-4
Giffordia granulosa (Sm.) Hamel		X			X	X	X	X	X	X	X	X	Ann.	1-4
Giffordia sandriana (Zanar.) Hamel								X	X				Ann.	2, 4
Giffordia secunda (Kütz.) Batt.								X					Ann.	2
Hecatonema terminalis (Kütz.) Kylin													Ann.	2?
Isthmoplea sphaerophora (Carm. *ex* Harv. *in* Hook.) Kjellm.				X	X	X	X*	X					Ann.	1, 2*, 4
Laminaria digitata (Huds.) Lamour.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1-4

Table II: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Laminaria longicruris Pyl.		X	X	X	X	X	X	X	X	X	X		Per.	1, 2, 4
Lamanaria saccharina (L.) Lamour.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Laminariocolax tementosoides (Farl.) Kylin			X	X				X		X		X	Ann. (?)	1, 2
Leathesia difformis (L.) Aresch.				X	X	X	X	X	X	X	X		Ann.	1, 2
Mikrosyphar porphyrae Kuck.					X		X	X					Ann.	1 (+ Cape Neddick, ME)
Myrionema corunnae Sauv.		X	X	X	X	X	X	X	X	X	X		Ann.	1, 2, 4
Myrionema magnusii (Sauv.) Lois.													Ann.	2?
Myrionema strangulans Grev.						X	X	X					Ann.	1, 2, 4
Petalonia fascia (O. F. Müll.) Kuntze	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1–4
Petalonia zosterifolia (Reinke) Kuntze			X	X	X			X			X	X	Ann.	1, 2, 4
Petroderma maculiforme (Wolny) Kuck.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	2, 4
Pilayella littoralis (L.) Kjellm.	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1–4
Protectocarpus speciosus (Børgesen) kuck.		X	X	X	X	X	X		X	X	X		Ann. (?)	1, 2
Pseudolithoderma extensum (Crouan frat.) S. Lund	X	X	X	X	X	X	X	X	X	X	X		Per.	1, 2, 4
Punctaria latifolia Grev.						X	X	X	X	X			Ann.	4
Punctaria plantaginea (Roth) Grev.						X	X	X					Ann.	1, 2
"*Ralfsia bornetii* Kuck."		X	X	X	X	X		X	X		X		Per. (?)	1–4

Table II: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
"*Ralfsia clavata* (Harv. *in* Hook.) Crouan frat."			X	X		X	X	X	X	X	X	X	Per. (?)	1-4
Ralfsia fungiformis (Gunn.) Setch. *et* Gardn.		X			X	X	X	X		X			Per.	2, 4
Ralfsia verrucosa (Aresch.) J. Ag.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1-4
Saccorhiza dermatodea (Pyl.) J. Ag.					X	X	X	X					Ann.	1, 2
Scytosiphon lomentaria (Lyngb.) Link var. *complanatus* Rosenv.		X	X										Ann.	4
Scytosiphon lomentaria (Lyngb.) Link var. *lomentaria*	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1-4
Sorapion kjellmanii (Wille) Rosenv.								X					Per.	2 (+ York River, ME)
Sorocarpus micromorus (Bory) Silva						X							Ann.	4
Sphacelaria arctica Harv.				X			X	X	X		X		Per. (?)	2
Sphacelaria cirrosa (Roth) C. Ag.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Sphacelaria fusca (Huds.) S. F. Gray							X						Per. (?)	1
Sphacelaria plumigera Holmes							X	X					Per.	2
Sphacelaria plumosa Lyngb.							X	X	X				Per. (?)	2
Sphacelaria radicans (Dillw.) C. Ag.	X	X	X		X	X	X	X	X	X	X		Per.	2, 3
Sphaerotrichia divaricata (C. Ag.) Kylin											X*		Ann.	2*
Spongonema tomentosum (Huds.) Kütz.)		X	X	X	X		X	X	X	X	X		Per. (?)	1, 2, 4

Table II: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Stictyosiphon griffithsianus (Le Jol.) Holm. *et* Batt.					X	X							Ann.	4
Ulonema rhizophorum Fosl.		X	X	X	X	X	X	X			X		Ann.	1, 2, 4
Montly total Phaeophyta taxa	25	34	36	43	46	48	50	55	42	36	38	27		

Table III: Seasonal occurrence, longevity and local distribution of Rhodophyceae

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Ahnfeltia plicata (Huds.) Fries	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Antithamnion cruciatum (C. Ag.) Näg.		X	X	X	X	X	X	X	X	X	X	X	Ann.	2, 4
Antithamnionella floccosa (O. F. Müll.) Whittick	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1, 2, 4
Audouinella alariae (Jónss.) Woelk.						X	X	X			X		Ann.	1, 2
Audouinella membranacea (Magn.) Papenf.	X	X	X	X	X	X	X	X	X	X	X	X	Per. (?)	1, 2, 4
Audouinella polyides (Rosenv.) Garbary									X				Ann.	2
Audouinella purpurea (Lightf.) Woelk.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Audouinella secundata (Lyngb.) Dixon	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1–4
Audouinella violaceae (Kütz.) Hamel			X		X	X	X	X	X	X	X	X	Ann.	4
Bangia atropurpurea (Roth) C. Ag.	X	X	X	X	X	X		X			X	X	Ann.	1, 2, 4
Bonnemaisonia hamifera Hariot			X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Callithamnion byssoides Arnott *ex* Harv. *in* Hook.									X	X			Ann.	4
Callithamnion hookeri (Dillw.) S. F. Gray							X	X	X				Ann.	1, 2, 4
Callithamnion tetragonum (With.) S. F. Gray	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Callocolax neglectus Schm. *ex* Batt.		X	X	X	X	X	X	X	X	X	X		Per. (?)	1, 2, 4
Callophyllis cristata (C. Ag.) Kütz.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Ceramium deslongchampii Chauv. *in* Duby var. *hooperi* (Harv.) Tayl.		X		X	X	X	X	X	X	X	X		Per. (?)	1, 2, 4

Table III: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Ceramium elegans (Ducluz.) C. Ag.								X					Ann.	4
Ceramium rubrum (Huds.) C. Ag.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Ceramium strictum Harv.		X			X	X	X	X	X	X	X	X	Ann.	2–4
Ceratocolax hartzii Rosenv.	X	X	X	X	X		X	X	X	X	X	X	Per.	1, 2
Chondria baileyana (Mont.) Harv.						X	X	X	X	X	X		Ann.	2, 4
Chondrus crispus Stackh.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Choreocolax polysiphoniae Reinsch	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Clathromorphum circumscriptum (Strömf.) Fosl.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Corallina officinalis L.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
"*Cruoriopsis ensis* Jao"							X				X		Per. (?)	2, 4
Cystoclonium purpureum (Huds.) Batt.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Dasya baillouviana (Gmel.) Mont.	X**	X**				X	X	X	X	X	X	X	Ann.	4
Dermatolithon pustulatum (Lamour.) Fosl.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Devaleraea ramentaceum (L.) Guiry	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2
Dumontia contorta (Gmel.) Rupr.	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1–4
Erythropeltis discigera (Berth.) Schm. var. *discigera*		X						X					Ann.	1, 2
Erythrotrichia carnea (Dillw.) J. Ag.		X		X		X	X	X	X	X	X		Ann.	1–4

Table III: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Fosliella lejolisii (Rosan.) Howe	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Gigartina stellata (Stackh.) Batt.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Gloiosiphonia capillaris Carm. *in* Berk.					X	X	X	X					Ann.	1, 2, 4
Goniotrichum alsidii (Zanard.) Howe				X				X	X	X	X		Ann.	1, 4
Gracilaria tikvahiae McLachlan	X	X	X	X	X	X	X	X	X	X	X	X	Per.	4
Gymnogongrus crenulatus (Turn.) J. Ag.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Halosacciocolax kjellmanii S. Lund					X								Per. (?)	1
Harveyella mirabilis (Reinsch.) Schm. *et* Reinke *in* Reinke						X			X	X	X		Per.	1, 2
Hildenbrandia rubra (Sommerf.) Menegh.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Leptophytum foecundum (Kjellm.) Adey	X	X		X	X	X	X	X	X	X	X	X	Per.	1, 2
Leptophytum laeve (Strömf.) Adey	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Lithophyllum corallinae (Crouan frat.) Heydr.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Lithothamnion glaciale Kjellm.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Lomentaria baileyana (Harv.) Farl.						X	X	X	X	X	X	X	Ann.	4
Lomentaria clavellosa (Turn.) Gaillon	X	X		X	X	X	X	X	X	X	X	X	Per. (?)	4 (+ Boone I., Maine
Lomentaria orcadensis (Harv.) Coll. *ex* Tayl.				X			X	X	X	X	X		Per	1, 2, 4
Membranoptera alata (Huds.) Stackh.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4

Table III: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Nemalion helminthoides (Vell. *in* With.) Batt.						X	X	X					Ann.	1, 2
Palmaria palmata (L.) O. Kuntze	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Pantoneura baeri (Post. *et* Rupr.) Kylin					X	X							Per.	1
"*Petrocelis cruenta* J. Ag."	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Peyssonnelia rosenvingii Schm. *in* Rosenv.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Phycodrys rubens (L.) Batt.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Phyllophora pseudoceranoides (Gmel.) New. *et* A. Tayl.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Phyllophora traillii Holm. *ex* Batt.						X	X	X		X	X		Per.	1, 2
Phyllophora truncata (Pallas) A. Zin.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Phymatolithon laevigatum (Fosl.) Fosl.		X		X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Phymatolithon lenormandii (Aresch. in J. Ag.) Adey	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Phymatolithon rugulosum Adey					X	X	X	X			X	X	Per.	1, 2
Plumaria elegans (Bonnem.) Schm.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–3
Polyides rotundus (Huds.) Grev.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Polysiphonia denudata (Dillw.) Kütz.		X		X		X	X	X	X	X	X	X	Ann.	3, 4
Polysiphonia elongata (Huds.) Spreng.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	2–4

Table III: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Polysiphonia flexicaulis (Harv.) Coll.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Polysiphonia harveyi Bailey	X	X				X	X	X	X	X	X	X	Ann.	1, 2, 4
Polysiphonia lanosa (L.) Tandy	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Polysiphonia nigra (Huds.) Batt.	X	X	X	X	X	X	X	X	X	X	X	X	Per. (?)	1–4
Polysiphonia nigrescens (Huds.) Grev.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Polysiphonia novae-angliae Tayl.	X							X				X	Per. (?)	1, 2
Polysiphonia subtilissima Mont.			X	X	X	X	X	X	X	X	X	X	Per.	3, 4
Polysiphonia urceolata (Lightf. *ex* Dillw.) Grev.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Porphyra leucosticta Thur. *in* Le Jol.	X	X	X	X	X	X	X	X	X		X	X	Ann.	1, 2, 4
Porphyra linearis Grev.	X	X	X	X	X					X		X	Ann.	1, 2, 4
Porphyra miniata (C. Ag.) J. Ag.			X	X	X	X	X	X	X				Ann.	1, 2, 4
Porphyra umbilicalis (L.) J. Ag.	X	X	X	X	X	X	X	X	X	X	X	X	Ann.	1–4
"*Porphyrodiscus simulans* Batt."											X		Per. (?)	4
Porphyropsis coccinea (J. Ag. *ex* Arsesch.) Rosenv.		X						X			X*		Ann.	2
Pterothamnion plumula (Ellis) Näg.	X		X			X	X	X	X	X		X	AAnn.	1, 2, 4
Ptilota serrata Kütz.	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1–4
Rhodomela confervoides (Huds.) Silva		X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Rhodophyllis dichotoma (Lepesch.) Gobi	X	X	X	X	X	X	X	X	X	X			Per.	1, 2, 4

Table III: (Cont.)

Taxa	Month												Longevity	Local Distribution
	J	F	M	A	M	J	J	A	S	O	N	D		
Rhodophysema elegans (Crouan frat. *ex* J. Ag.) Dixon	X	X	X	X	X	X	X	X	X	X	X	X	Per.	1, 2, 4
Rhodophysema georgii Batt.		X	X	X	X		X	X	X				Per. (?)	4
Sacheria fucina (Bory) Sirodot	X	X		X	X	X	X	X	X	X	X	X	Per.	4
Scagelia corallina (Rupr.) Hansen *et* Scagel	X	X	X	X	X	X	X	X	X	X	X	X	AAnn.	1, 2, 4
Spermothamnion repens (Dillw.) Rosenv.			X					X		X			Ann.	1, 2
"*Trailliella intricata* Batt."			X	X		X	X	X		X	X		Per.	1, 4
Turnerella pennyi (Harv.) Schm.											X	X	Per.	2
Monthly total Rhodophyta taxa	56	65	60	66	67	75	77	83	74	73	76	66		
Monthly grand total seaweed taxa	105	131	132	143	146	159	169	178	146	146	148	120		

Table IV: Summary of collection sites

Geographical Area	No. and/or Names of Permanent Stations	Sites with at Least 2 yrs. of Seasonal Collections	Sites with at Least 2 yrs. of Monthly Collections	Pertinent References
1. Isles of Shoals				Mathieson (1979)
				Mathieson & Penniman (1986a)
				Norall et al. (1981)
	Appledore Island	X		
	Cedar Island	X		
	Duck Island	X		
	Lunging Island	X		
	Malaga Island	X		
	Smuttynose Island	X		
	Star Island	X		
	White Island	X		
2. Nearshore open coast	13 sites		X	Hehre & Mathieson
	Jaffrey Point, New Castle		X	Mathieson, Hehre, & Reynolds (1981)
	43°03′22″N, 70°42′49″W			Mathieson & Penniman (1986a,b)
				Mathieson, Reynolds & Hehre (1981)
	Bound Rock, Seabrook		X	Daly & Mathieson (1977)
	42°53′30″N, 70°48′45″W			Mathieson & Fralick (1972)
				Mathieson & Penniman (1986a,b)
3. Hampton-Seabrook Estuary System	49 total sites	X		Mathieson and Fralick (1972)
	Blackwater River—11 sites	X		
	Brown River—13 sites	X		

Table IV (Continued)

Geographical Area	No. and/or Names of Permanent Stations	Sites with at Least 2 yrs. of Seasonal Collections	Sites with at Least 2 yrs. of Monthly Collections	Pertinent References
	Hampton River—18 sites	X		
	Hampton Harbor—7 sites	X		
4. Great Bay Estuary System				Mathieson, Reynolds, & Hehre (1981)
	182 total sites	X		
	Great Bay—16 sites	X		
	Crommet Creek, Durham 43°05′52″N, 70°53′53″W		X	Daly & Mathieson (1981) Mathieson & Penniman (1986b)
	Nannies Island, Newington 43°04′08″N, 70°51′47″W		X	Mathieson & Penniman (1986b)
	Thomas Point, Newington 43°04′53″N, 70°51′56″W		X	Mathieson & Penniman (1986b)
	Weeks Point, Greenland 43°03′32″N, 70°51′42″W		X	Mathieson, Reynolds & Hehre (1981)
	Little Bay—21 sites	X		
	Adams Point, Durham 43°05′43″N, 70°52′07″W		X	Mathieson, Reynolds & Hehre (1981)
	Cedar Point, Durham 43°07′45″N, 70°51′08″W		X	Chock and Mathieson (1976, 1983) Mathieson & Penniman (1986b) Mathieson, Reynolds & Hehre (1981)
	Dover Point, Dover 43°07′07″N, 70°49′42″W		X	Mathieson et al. (1983) Mathieson & Penniman (1986a,b)

Table IV (Continued)

Geographical Area	No. and/or Names of Permanent Stations	Sites with at Least 2 yrs. of Seasonal Collections	Sites with at Least 2 yrs. of Monthly Collections	Pertinent References
				Mathieson, Reynolds & Hehre (1981) Reynolds & Mathieson (1975)
	Durham Point, Durham 43°07′14″N, 70°52′10″W		X	Mathieson & Penniman (1986b)
	Bellamy River—10 sites	X		
	Cocheco River—17 sites	X		
	Lamprey River—9 sites	X		
	Oyster River—14 sites	X		
	Headwater at route 108, Durham 43°07′52″N, 70°55′06″W		X	Mathieson & Penniman (1986b)
	Piscataqua River—59 sites	X		
	Atlantic Heights, Portsmouth 43°05′36″N, 70°46′08″W			Mathieson et al. (1977)
	Normandeau Schiller site #16, just east of the Schiller Power generating station, Portsmouth 43°05′41″N, 70°46′51″W		8 years of continuous seasonal collections	Normandeau Assoc. (1971–80)

Table IV (Continued)

Geographical Area	No. and/or Names of Permanent Stations	Sites with at Least 2 yrs. of Seasonal Collections	Sites with at Least 2 yrs. of Monthly Collections	Pertinent References
	Ibid., #17, at end of Long Reach Farm, Eliot, Maine 43°06′02″N, 70°46′52″W		8 years of continuous seasonal collections	Normandeau Assoc. (1971–80)
	Ibid., #20, near Schiller Power Plant, Newington 43°06′15″N, 70°47′47″W		8 years of continuous seasonal collections	Normandeau Assoc. (1971–80)
	Ibid., #40, near Simplex, Pier, Newington 43°06′15″N, 70°47′47″W		8 years of continuous seasonal collections	Mathieson & Penniman (1986b) Normandeau Assoc. (1971–80)
	Ibid. #44, area just west of Simplex Pier and Union Oil Terminal, Newington 43°06′28″N, 70°47′58″W		8 years of continuous seasonal collections	Normandeau Assoc. (1971–80)
	Salmon Falls River—16 sites	X		
	Squamscott River—16 sites			
	Chapman's Landing Route 108 bridge, Newfields 43°02′24″N, 70°55′43″W		X	Mathieson & Penniman (1986b) Mathieson, Reynolds & Hehre (1981)
	Winnicut River—4 sites	X		

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY
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FIGURES 16–229. SPECIES DISTRIBUTION MAPS FOR 214 TAXA FOUND WITHIN COASTAL–ESTUARINE WATERS OF NEW HAMSPHIRE AND SOUTHERN MAINE.

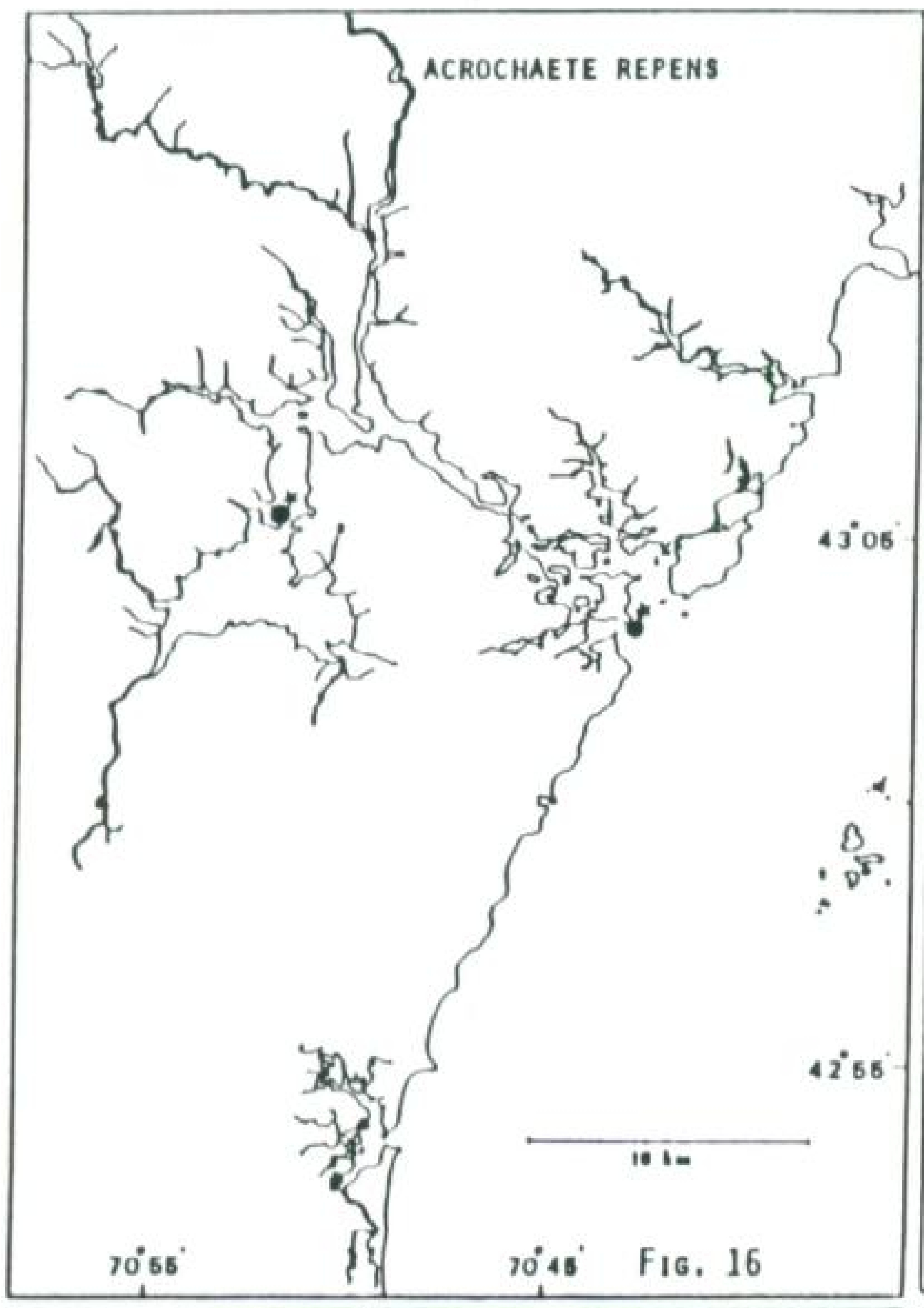


FIG. 16

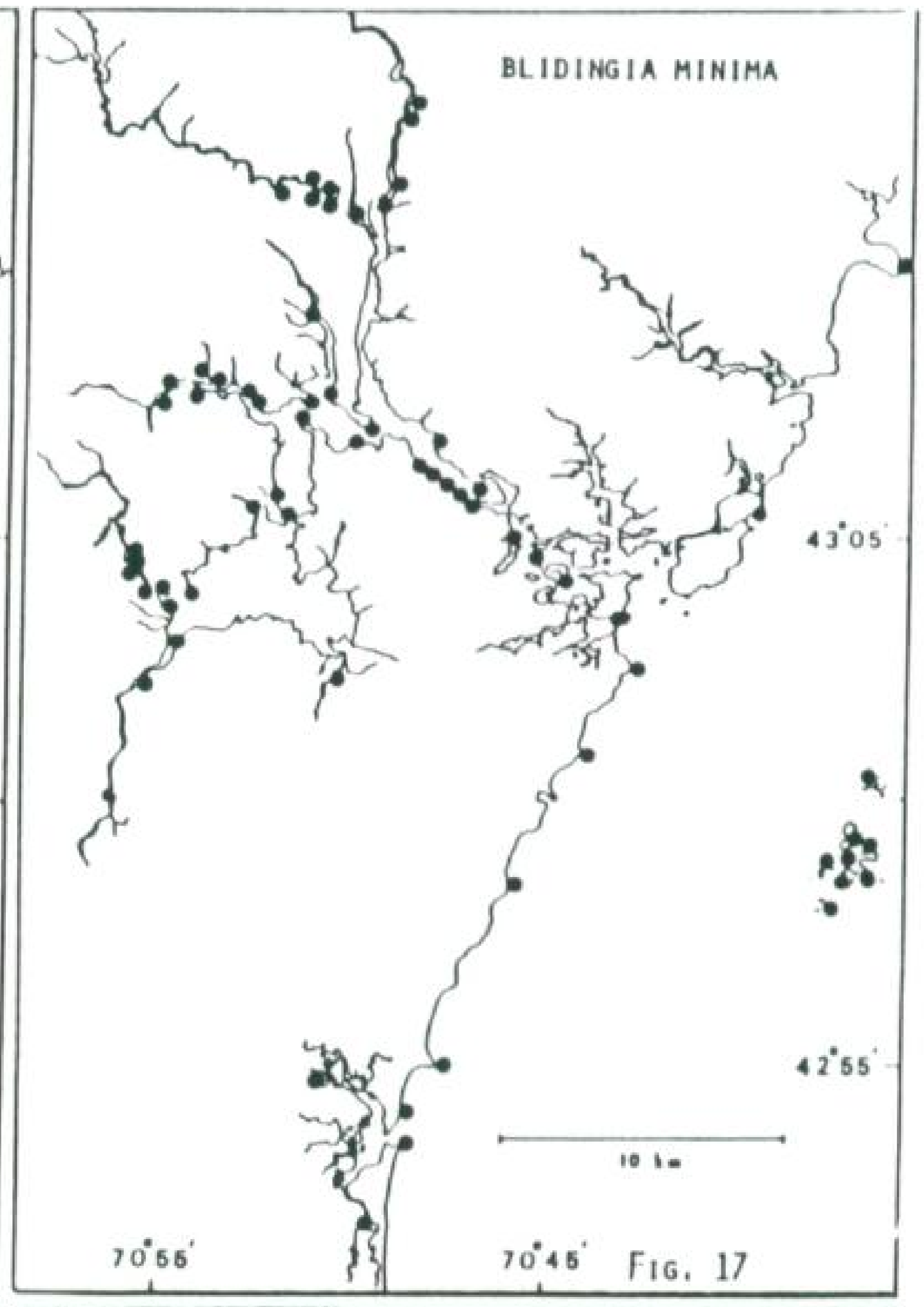


FIG. 17

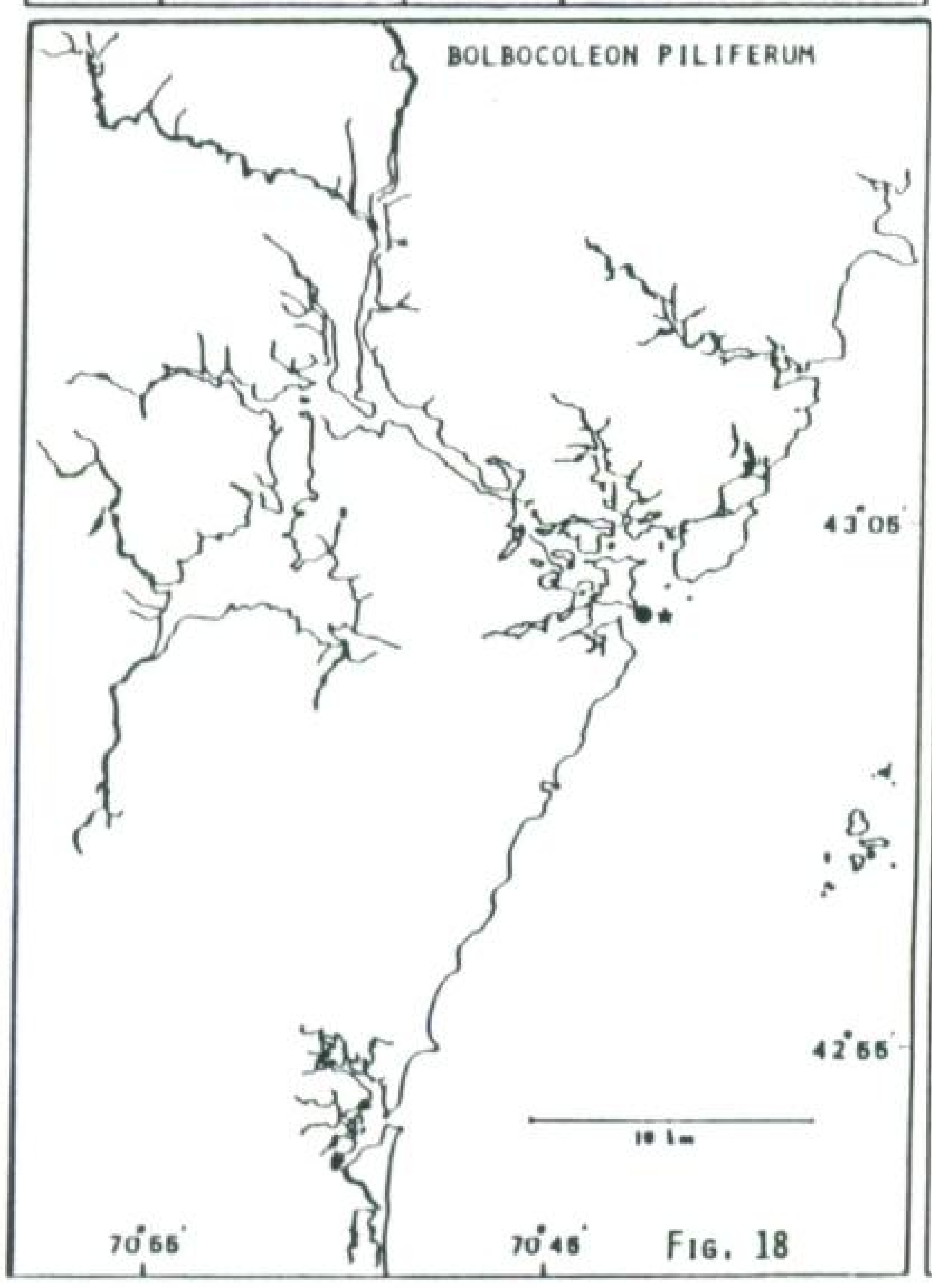


FIG. 18

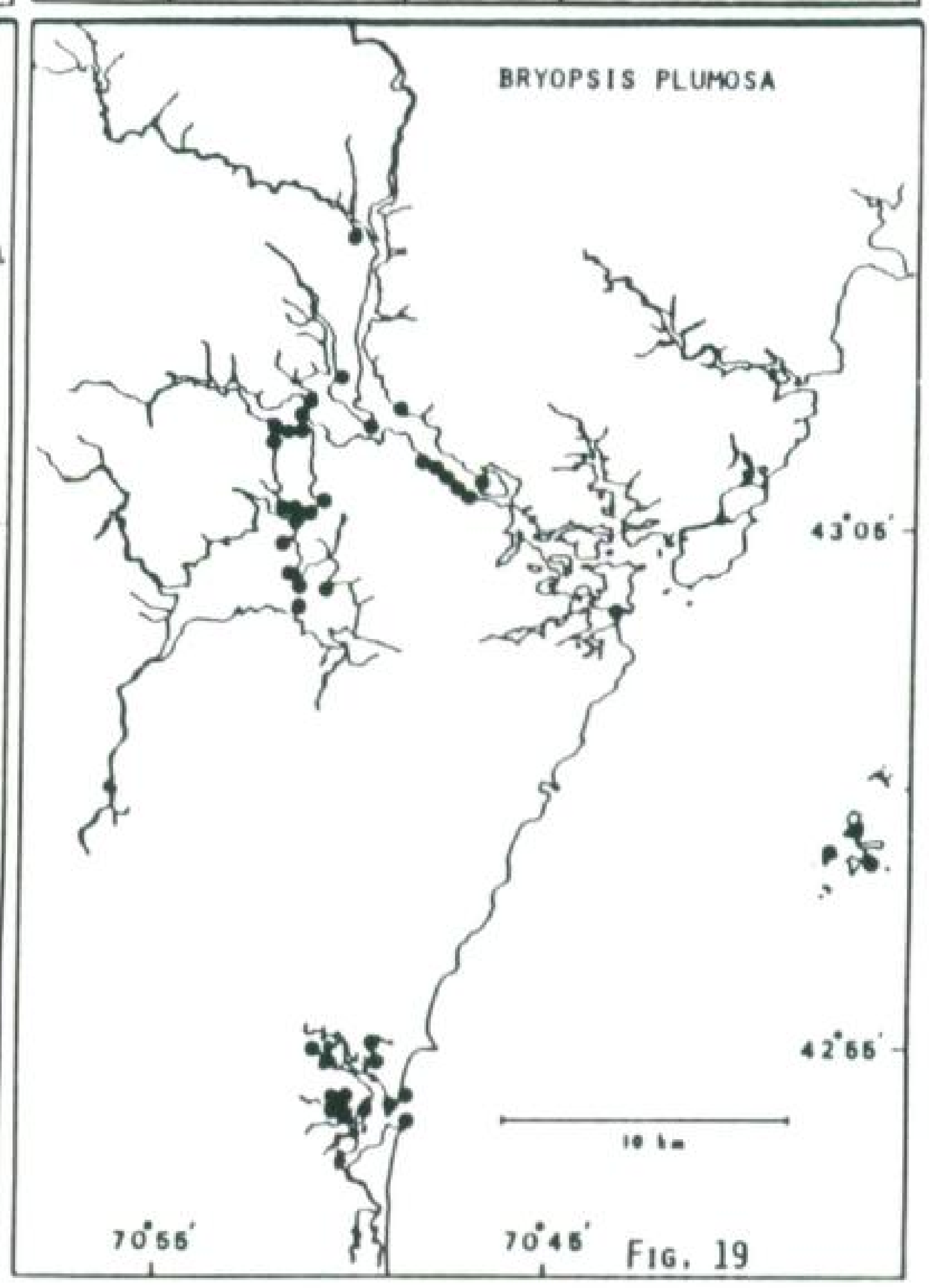


FIG. 19

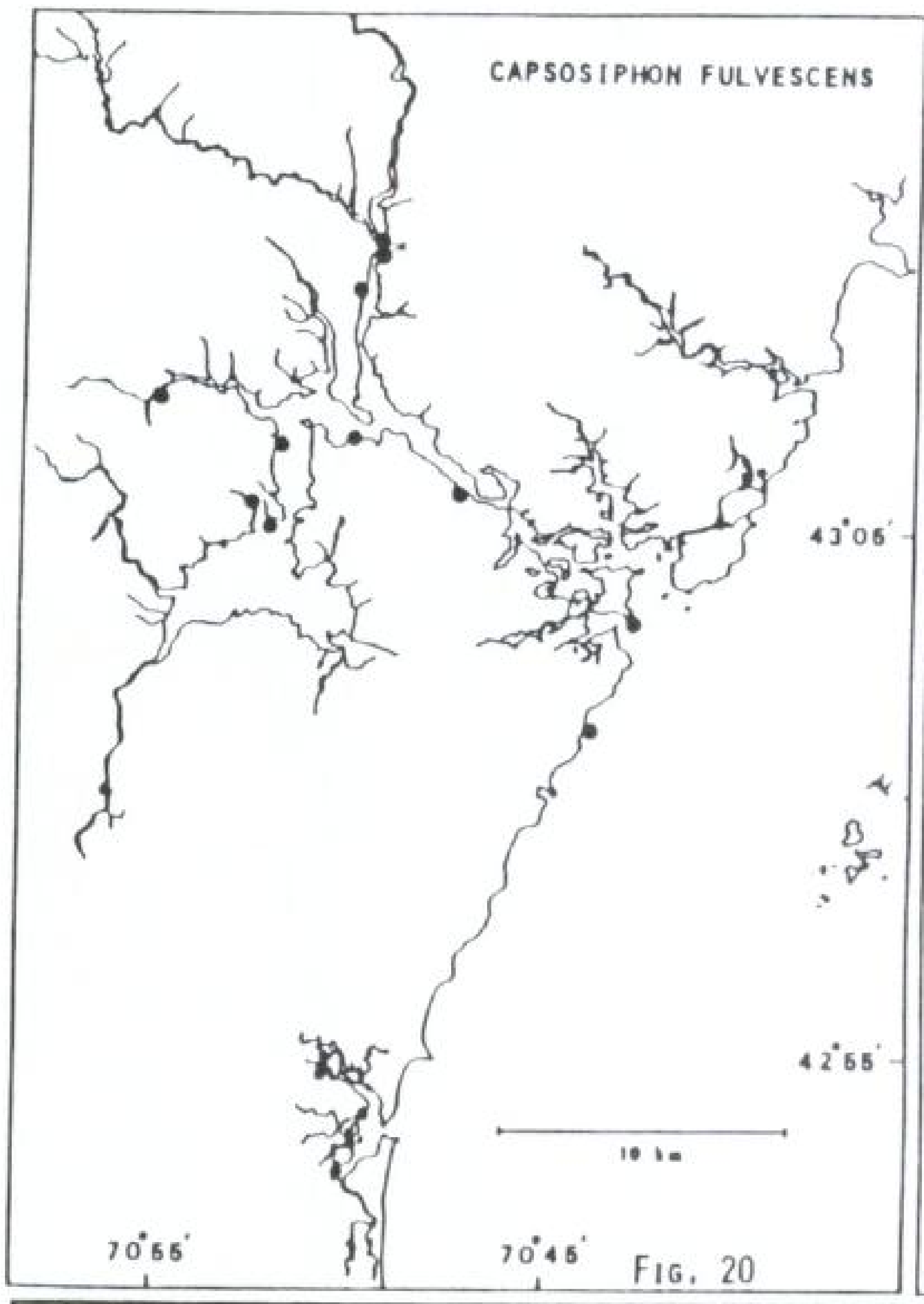


FIG. 20

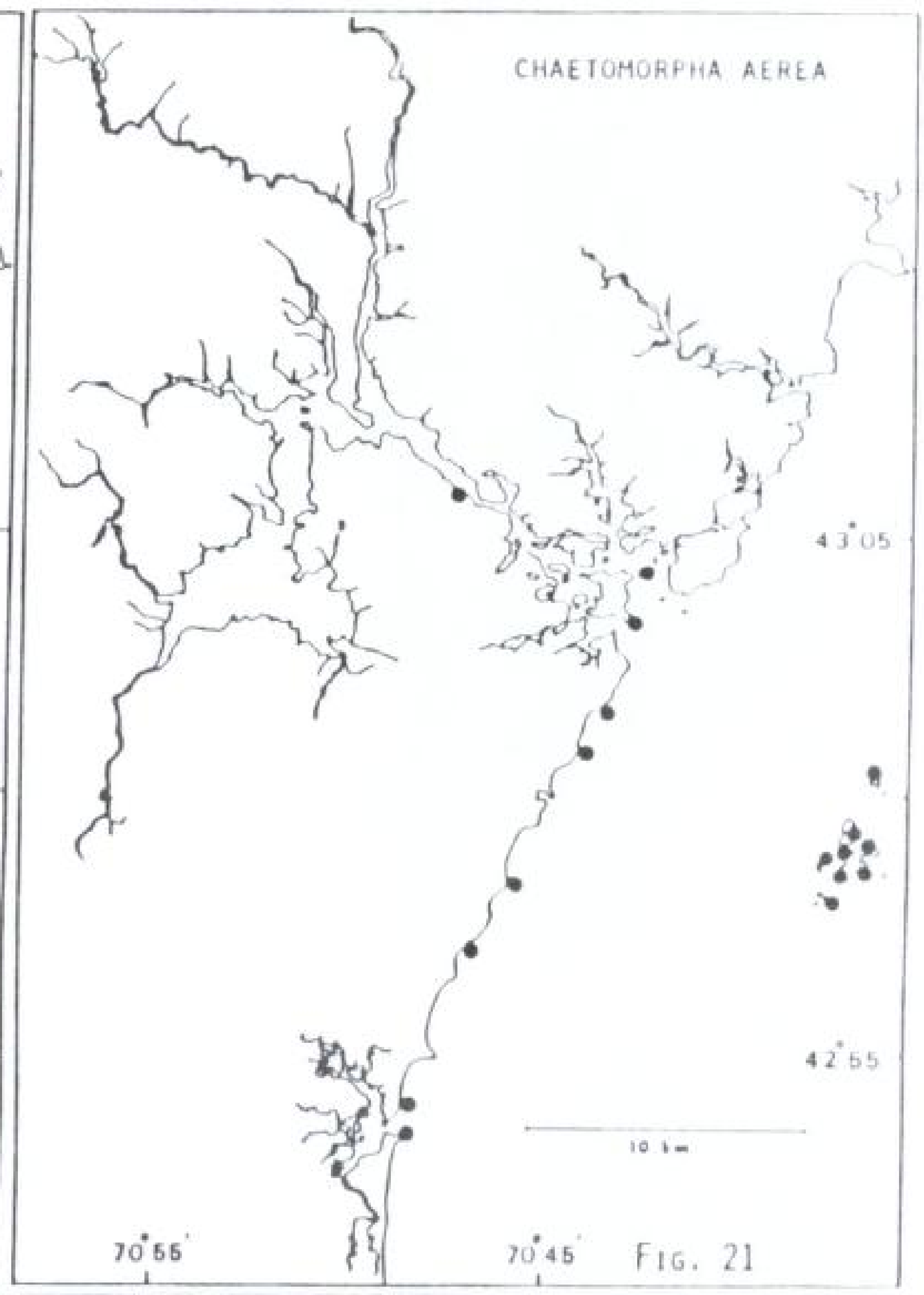


FIG. 21

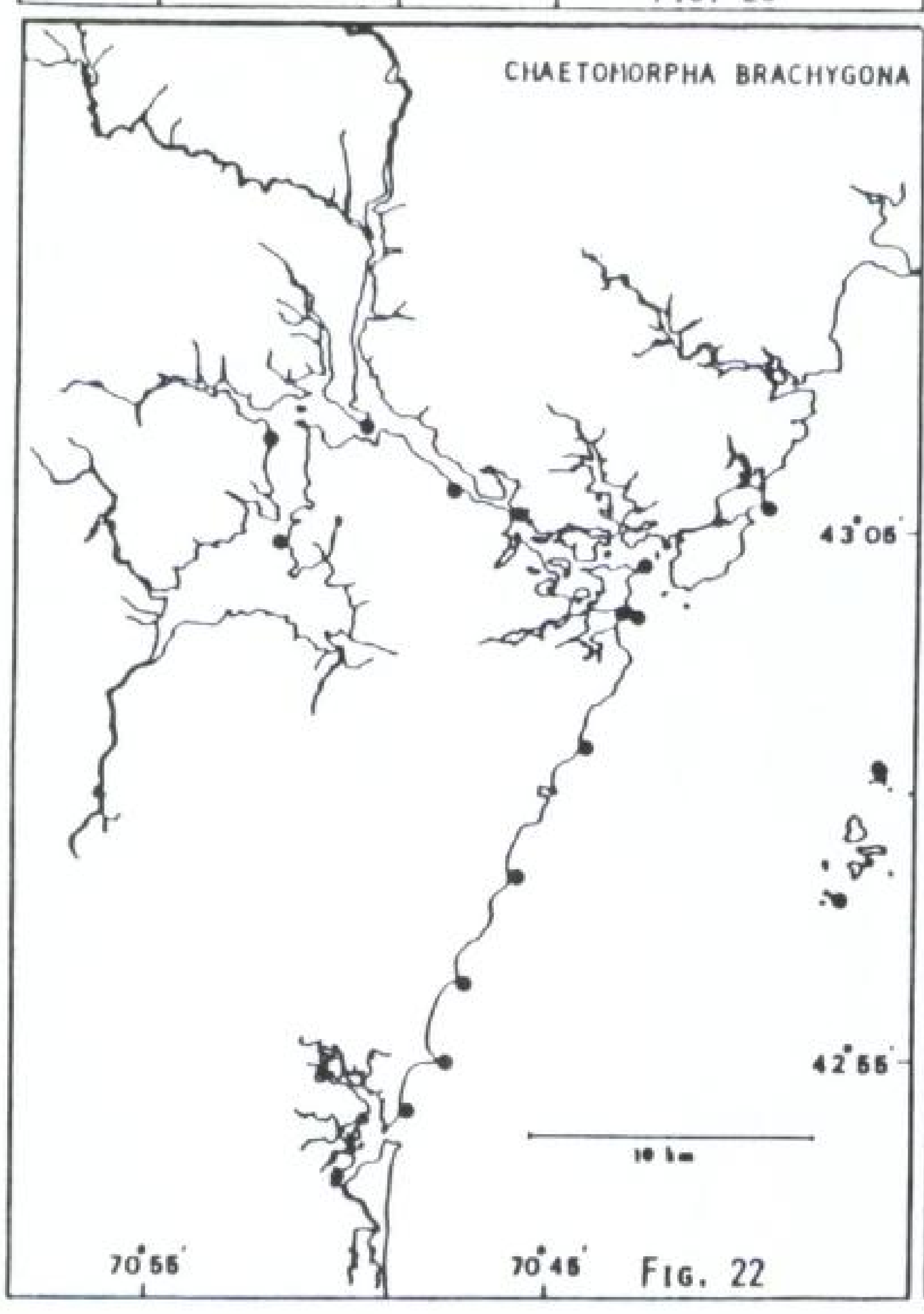


FIG. 22

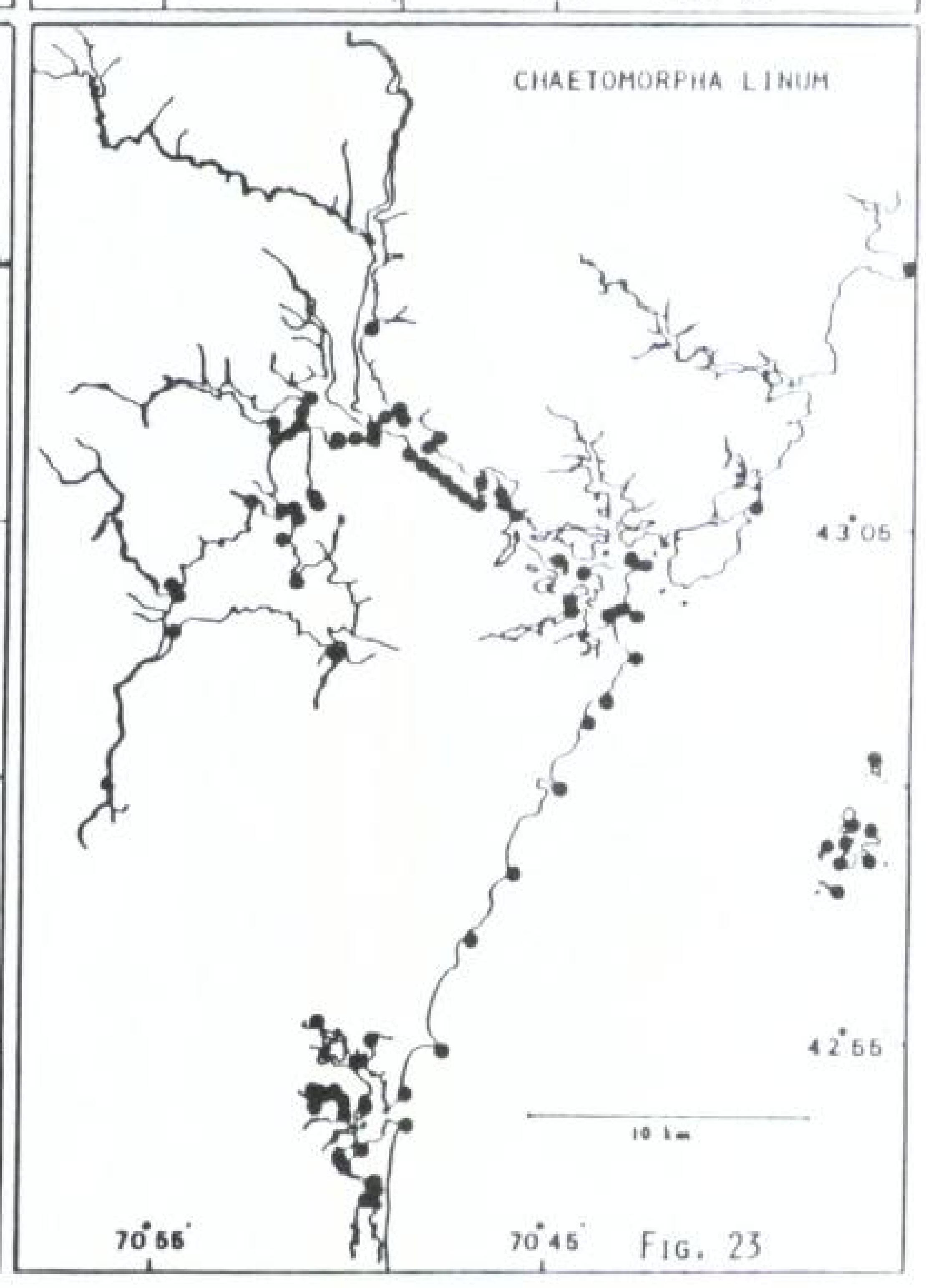


FIG. 23

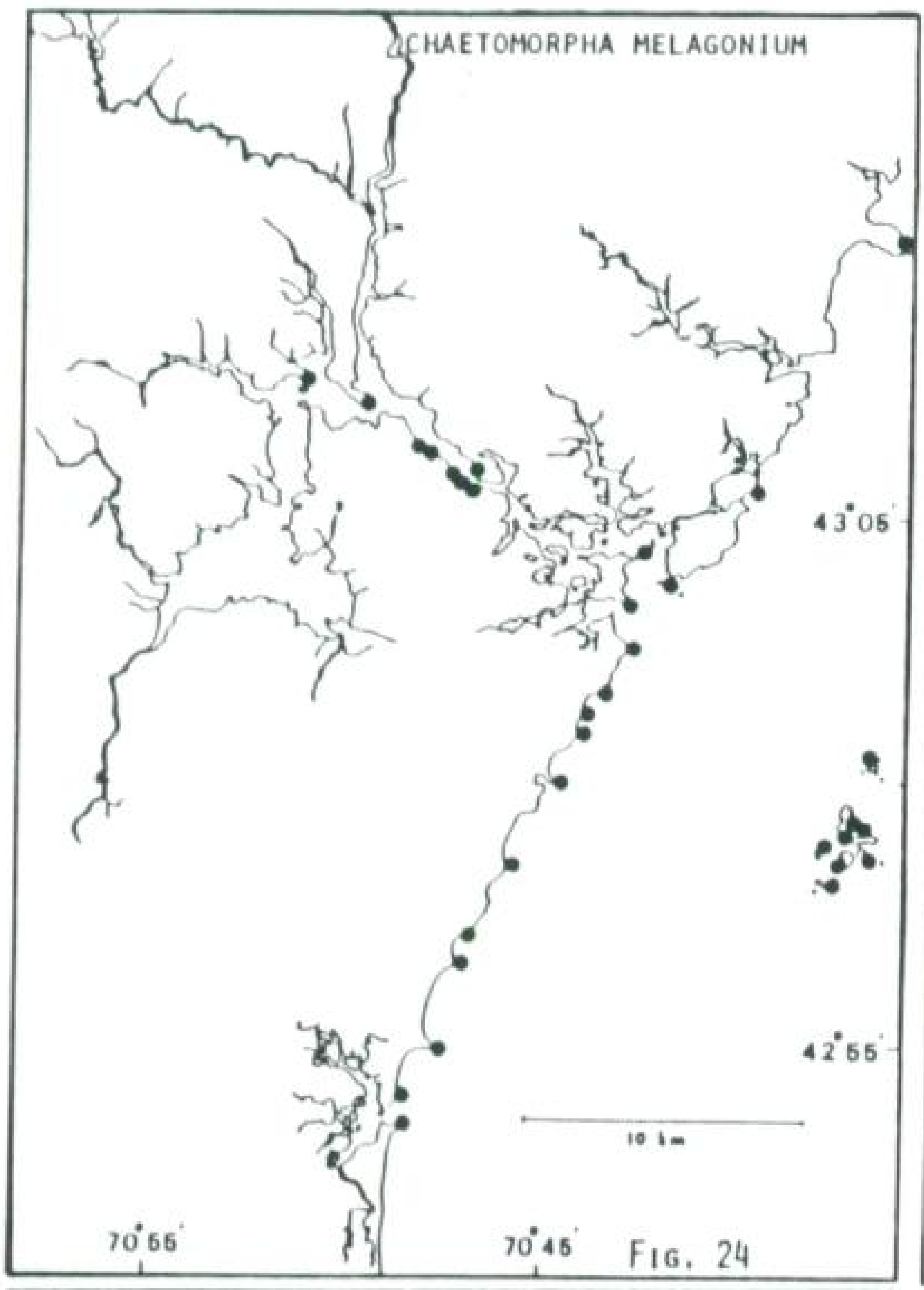


FIG. 24

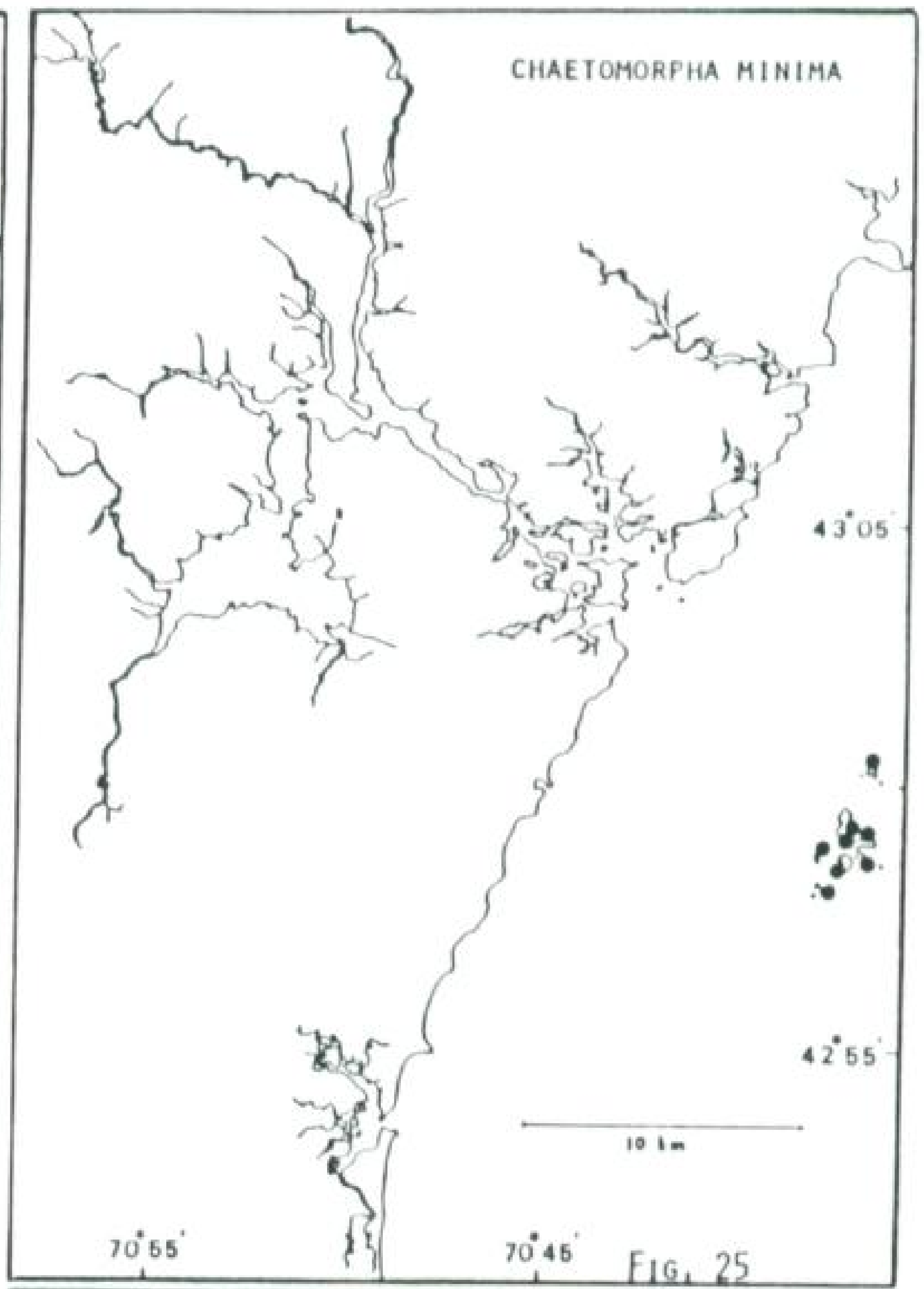


FIG. 25

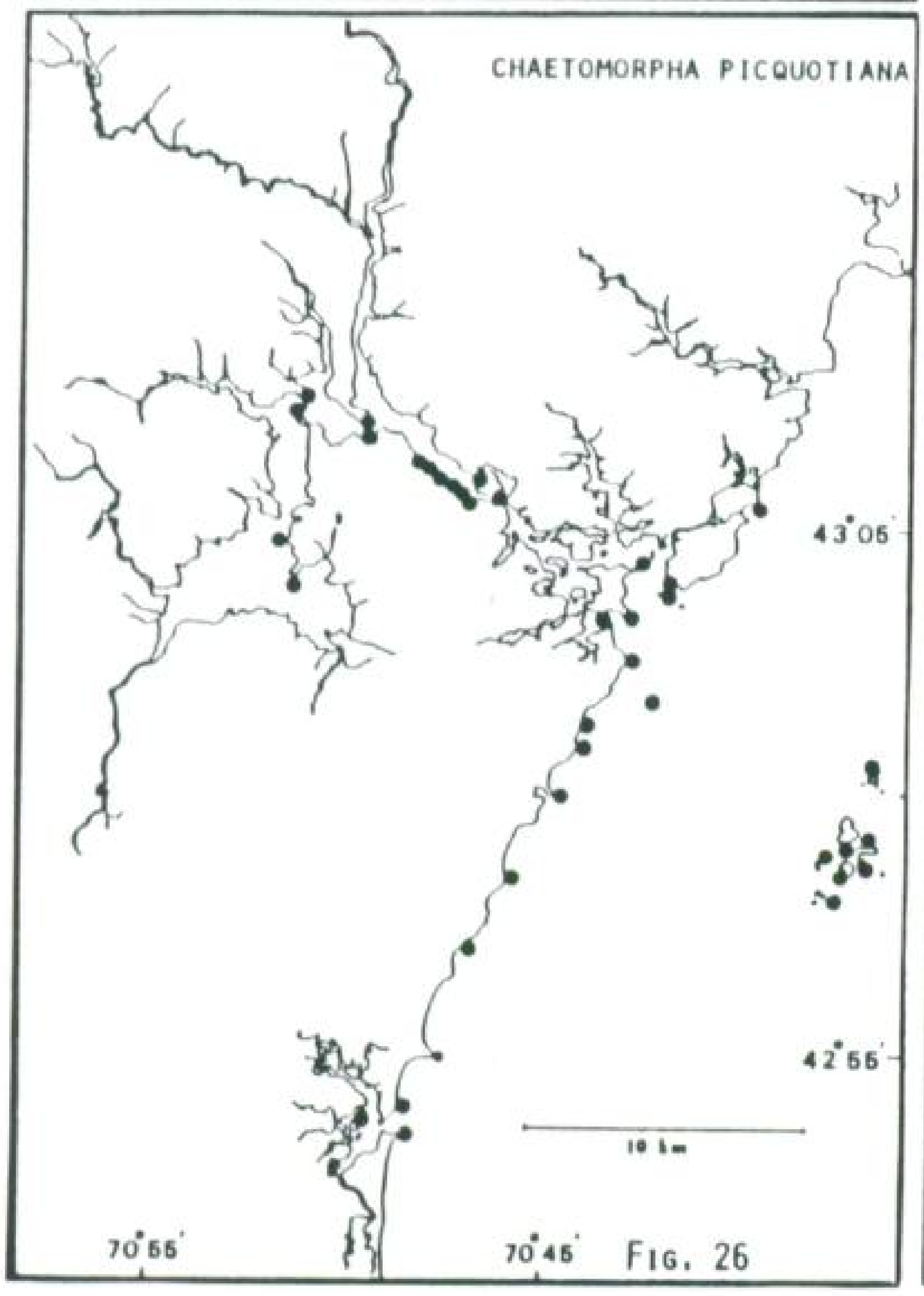


FIG. 26

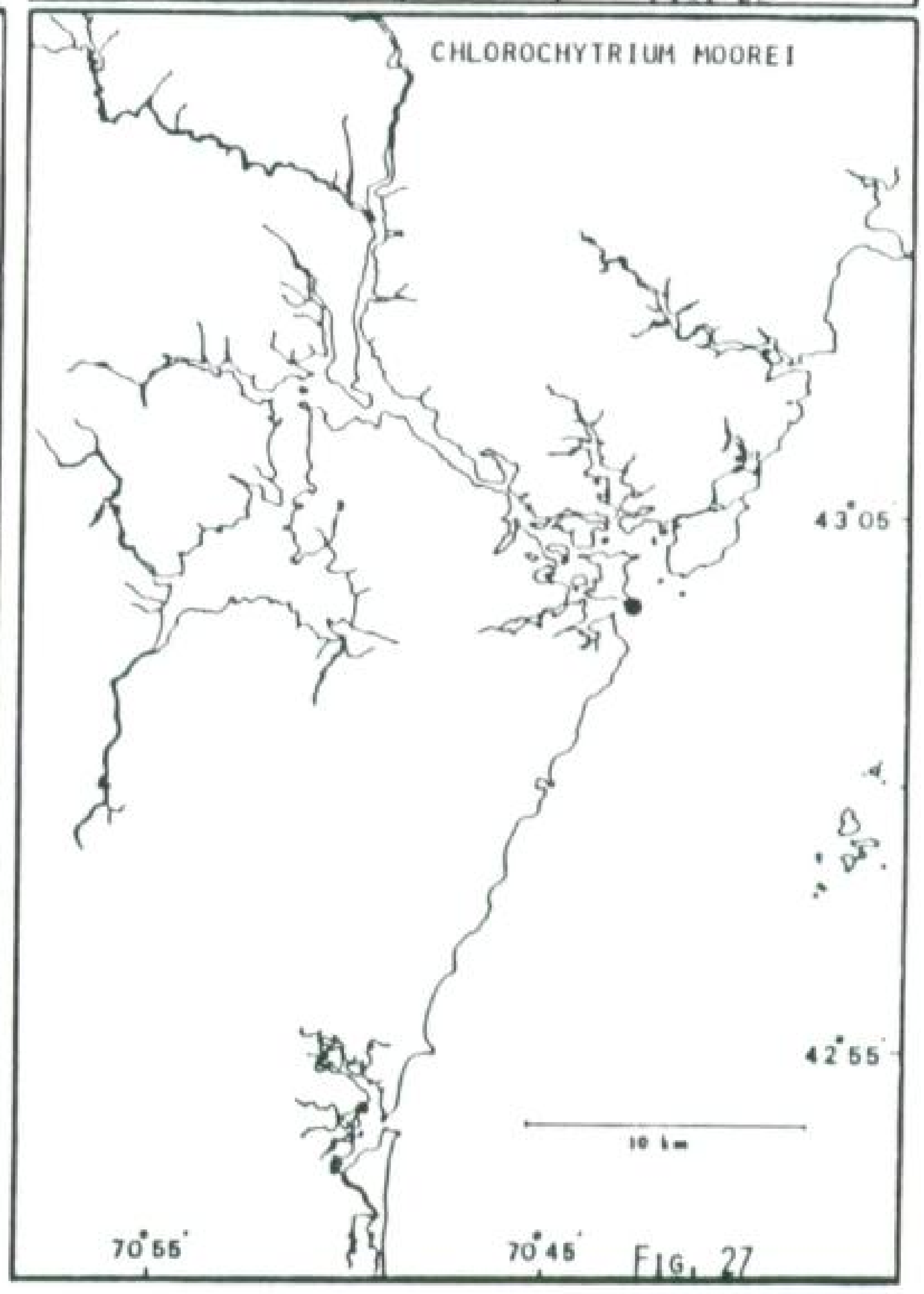


FIG. 27

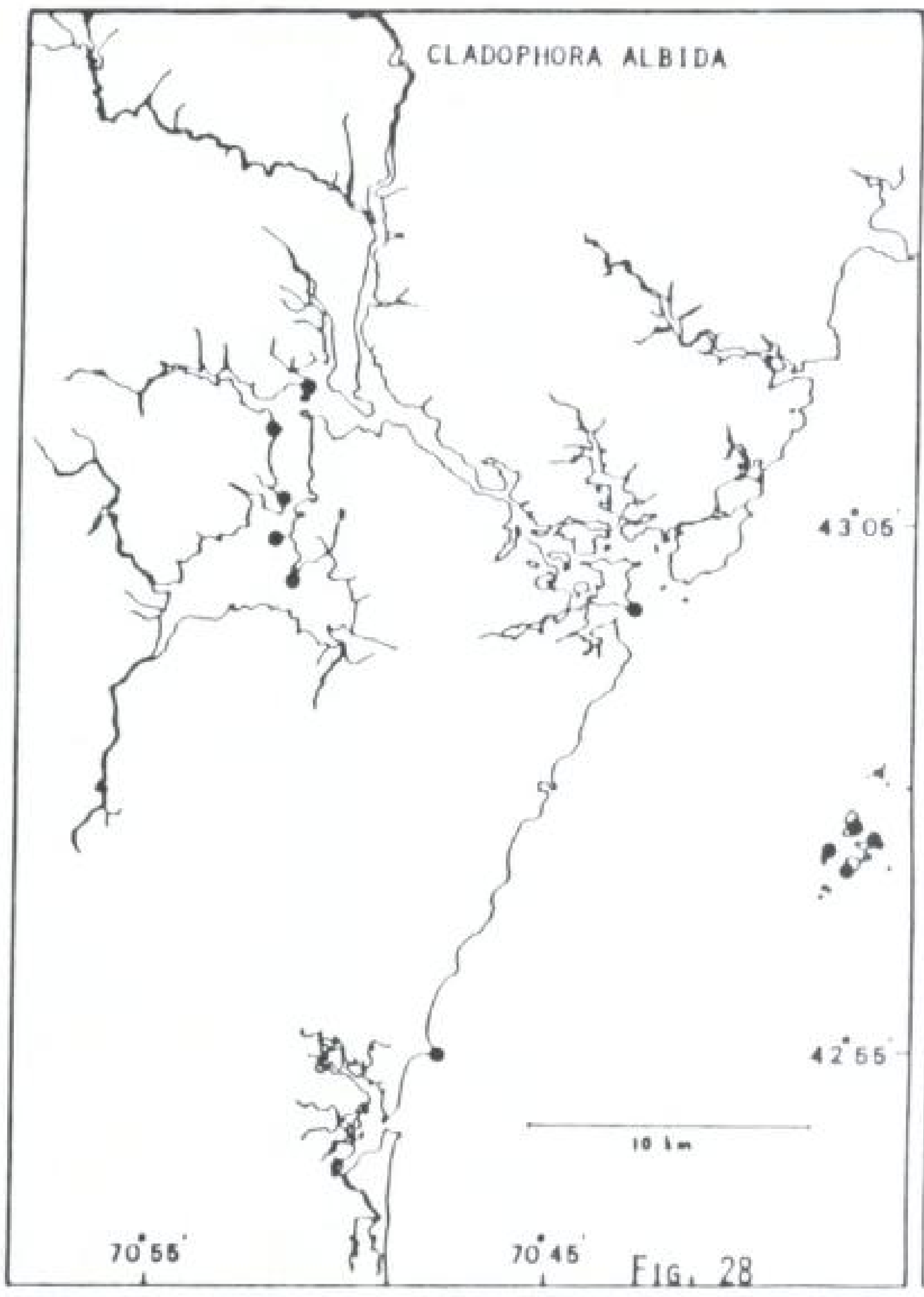


Fig. 28

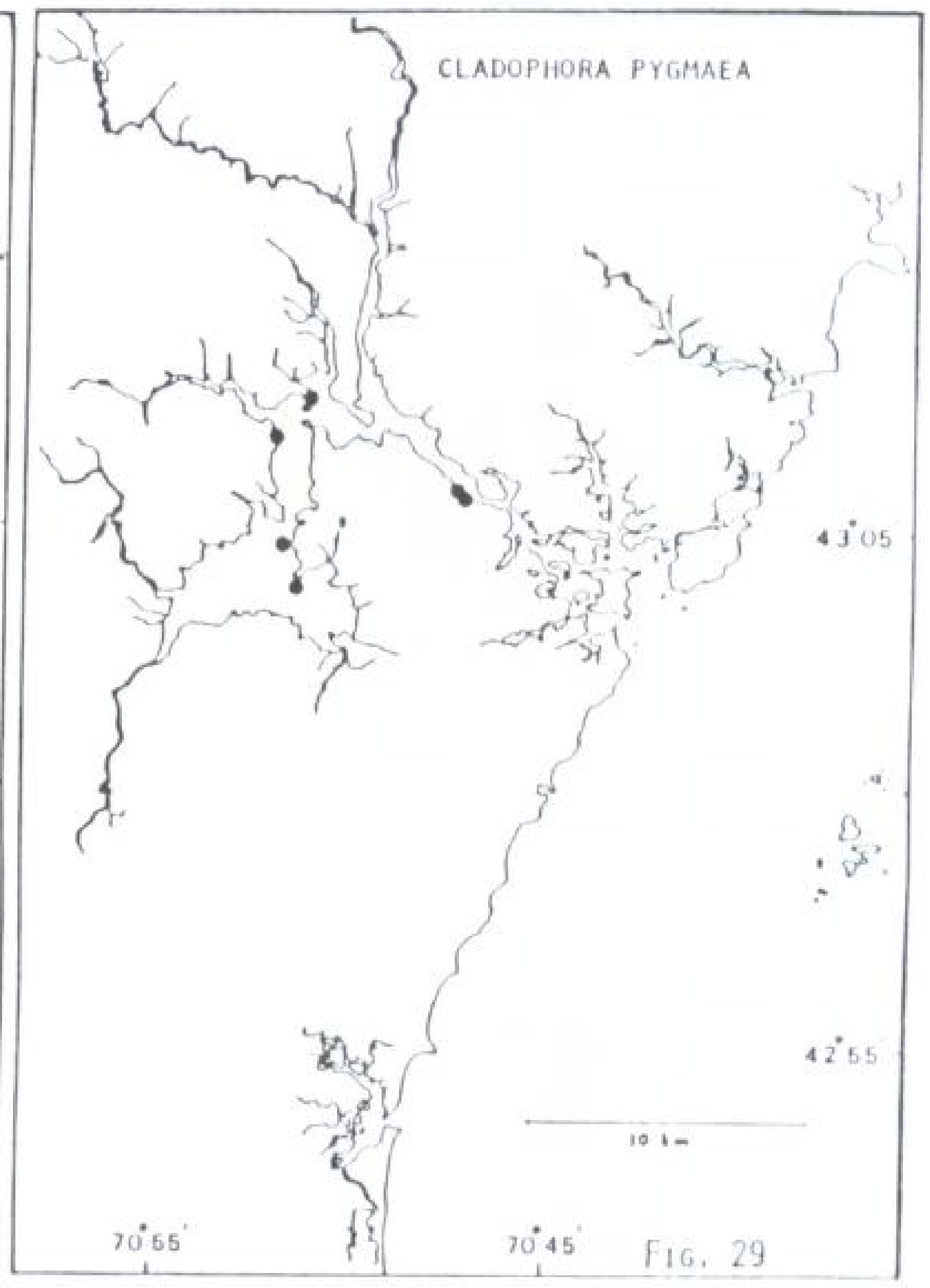


Fig. 29

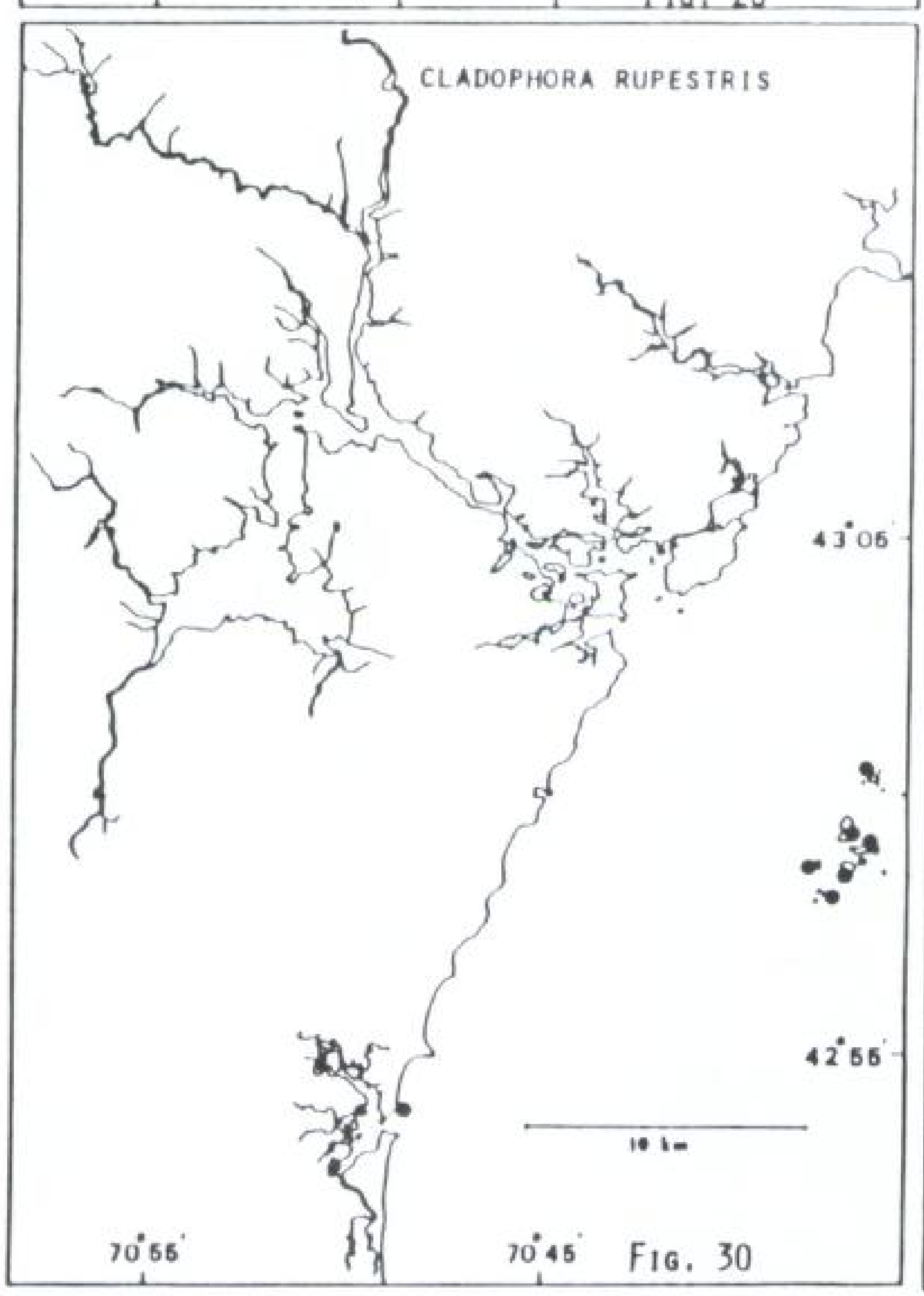


Fig. 30

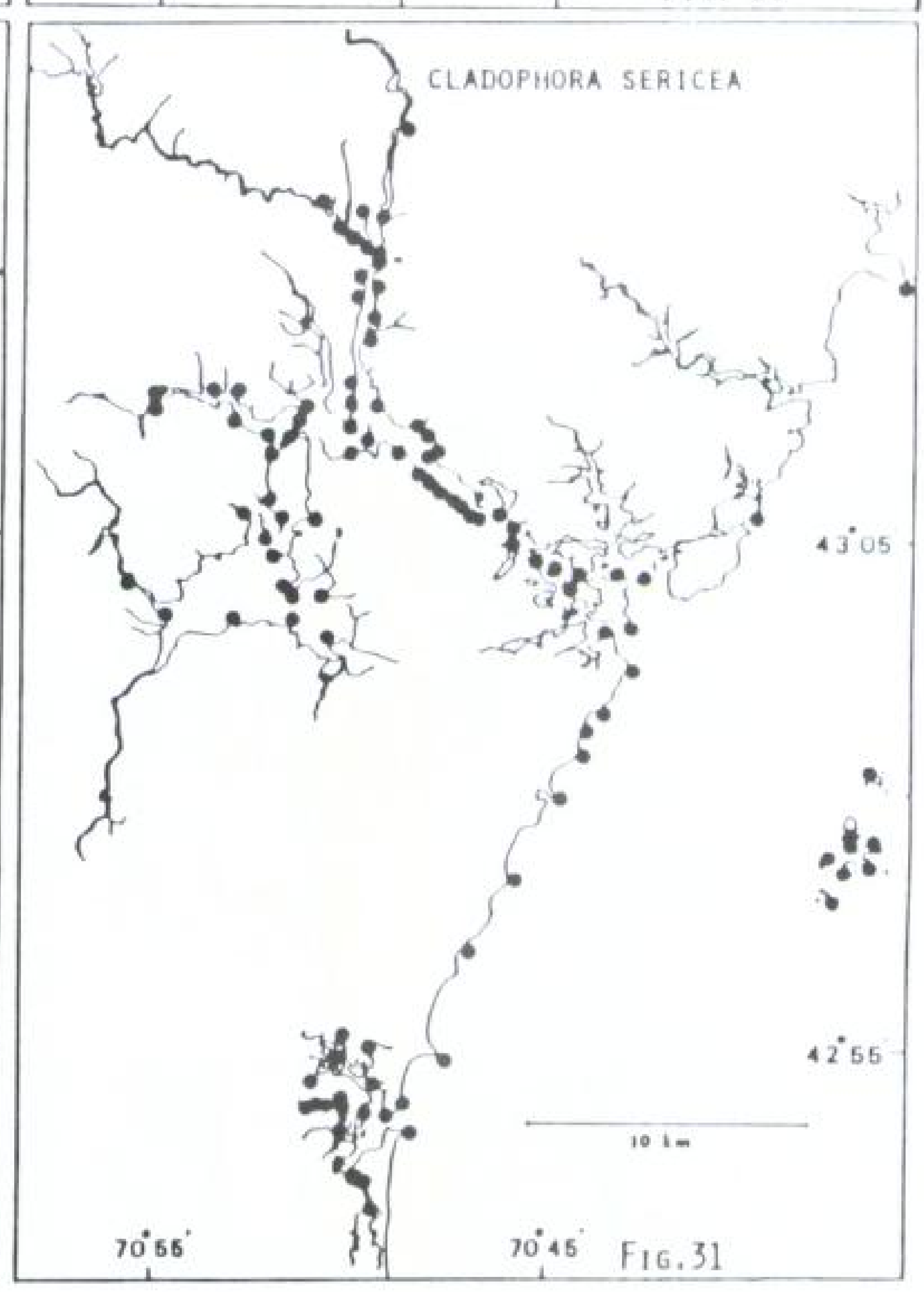


Fig. 31

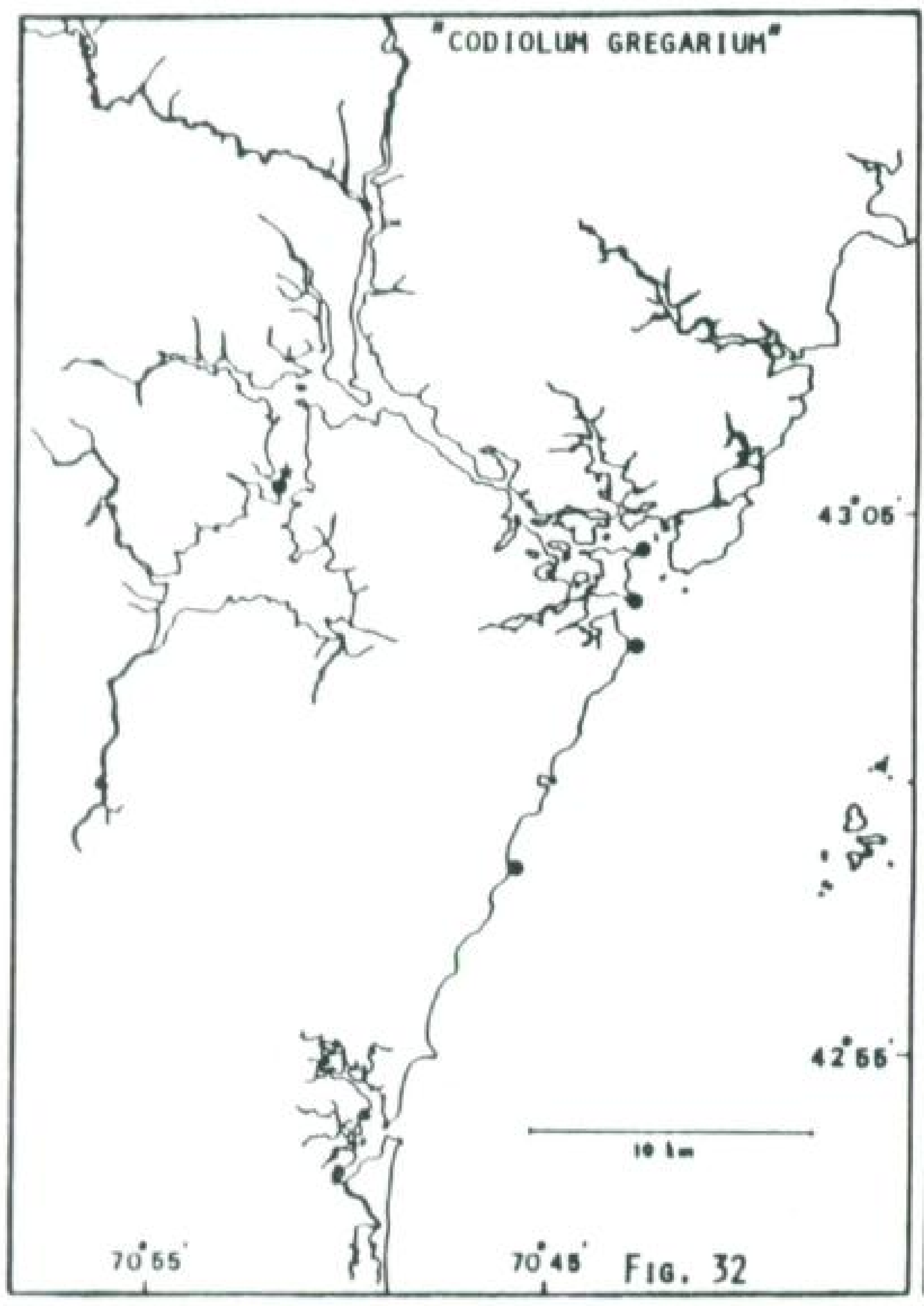


FIG. 32

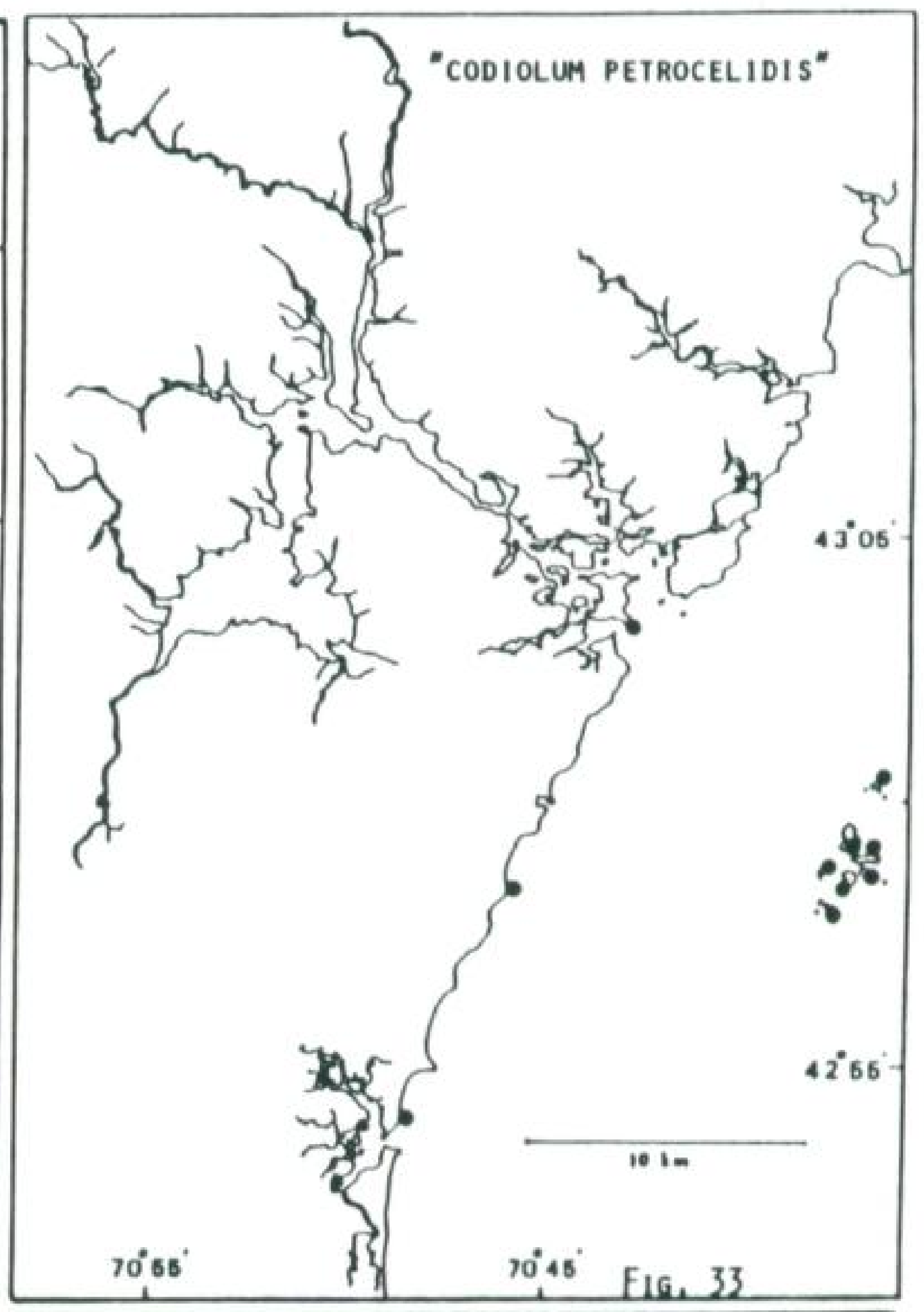


FIG. 33

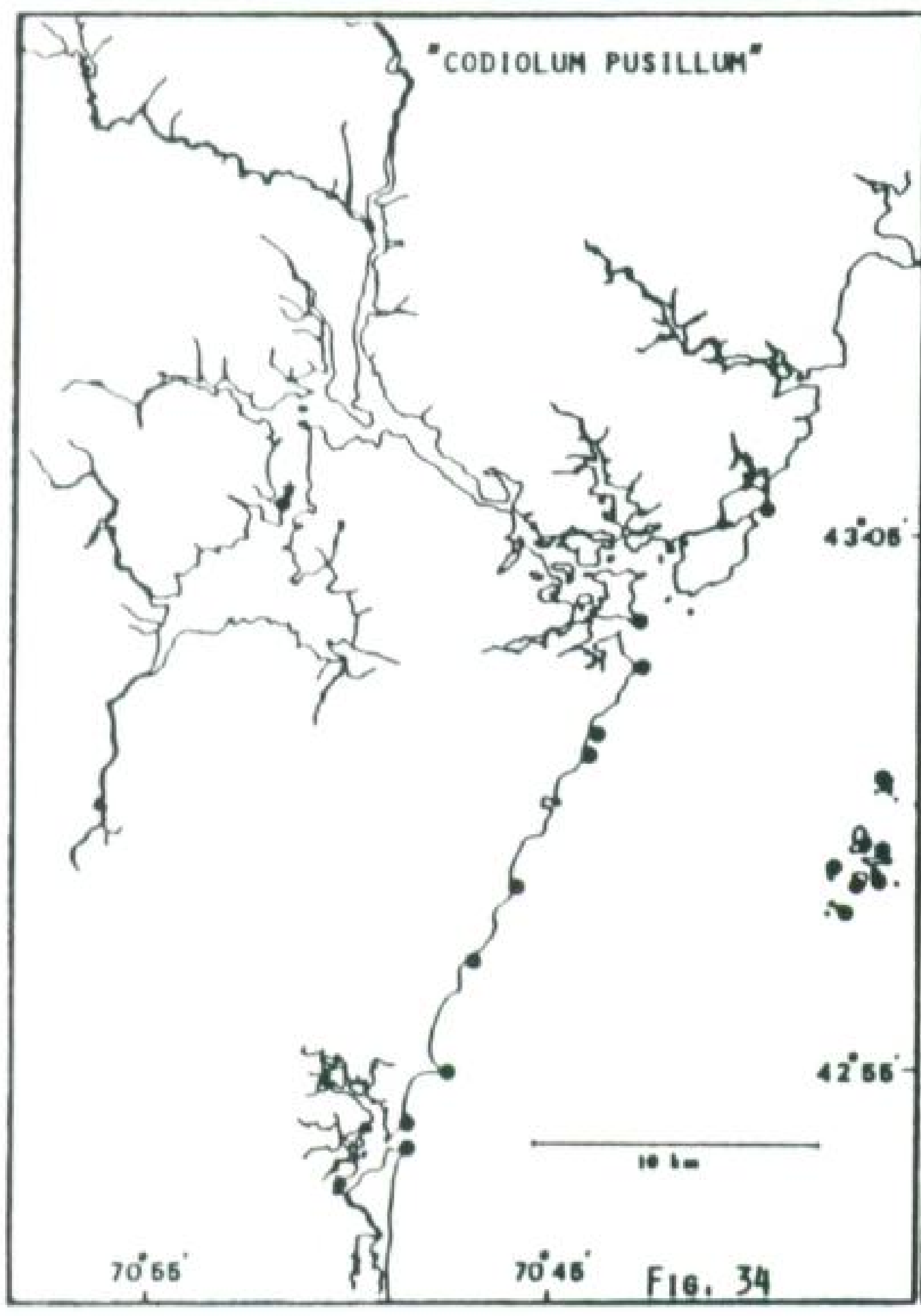


FIG. 34

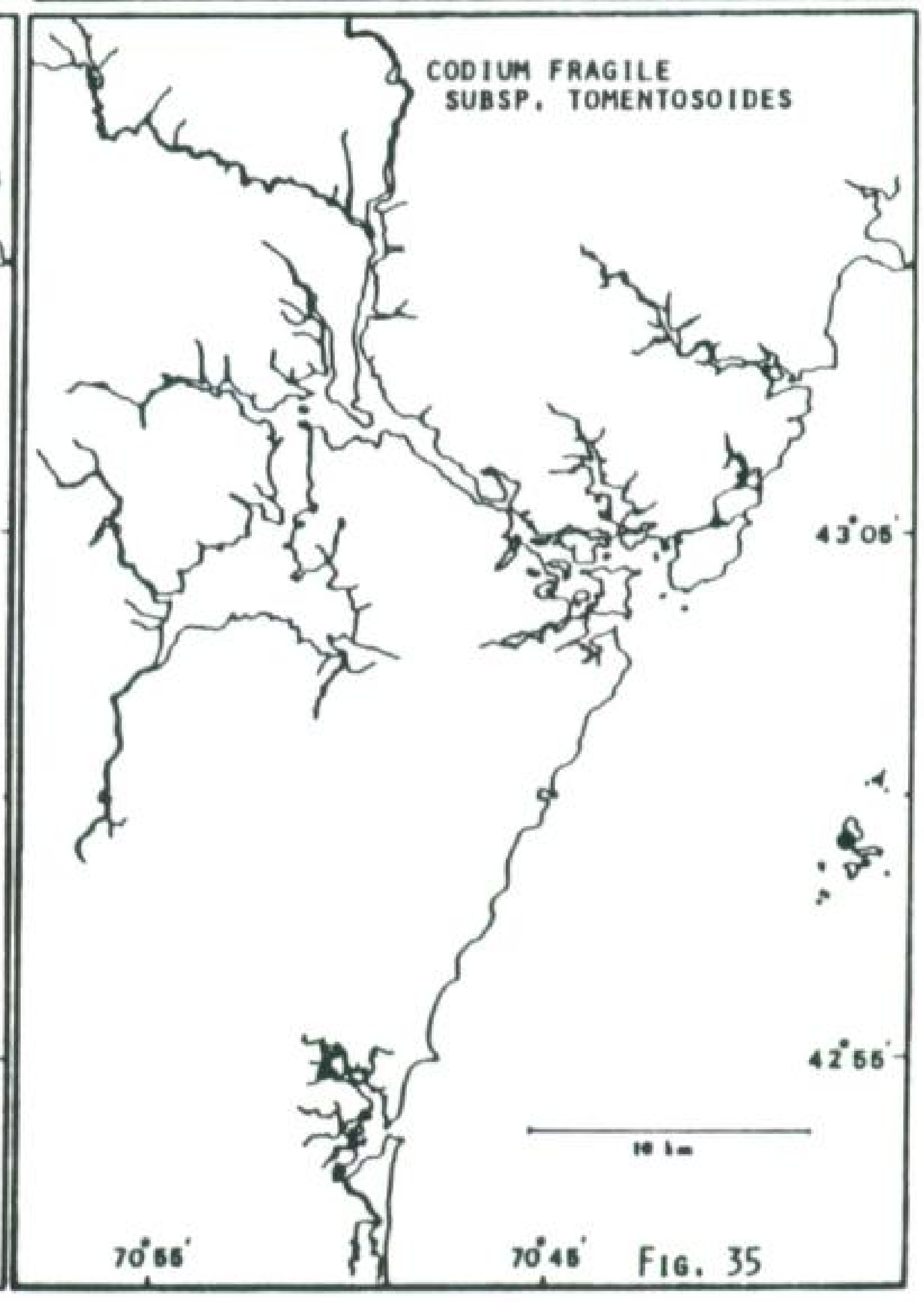


FIG. 35

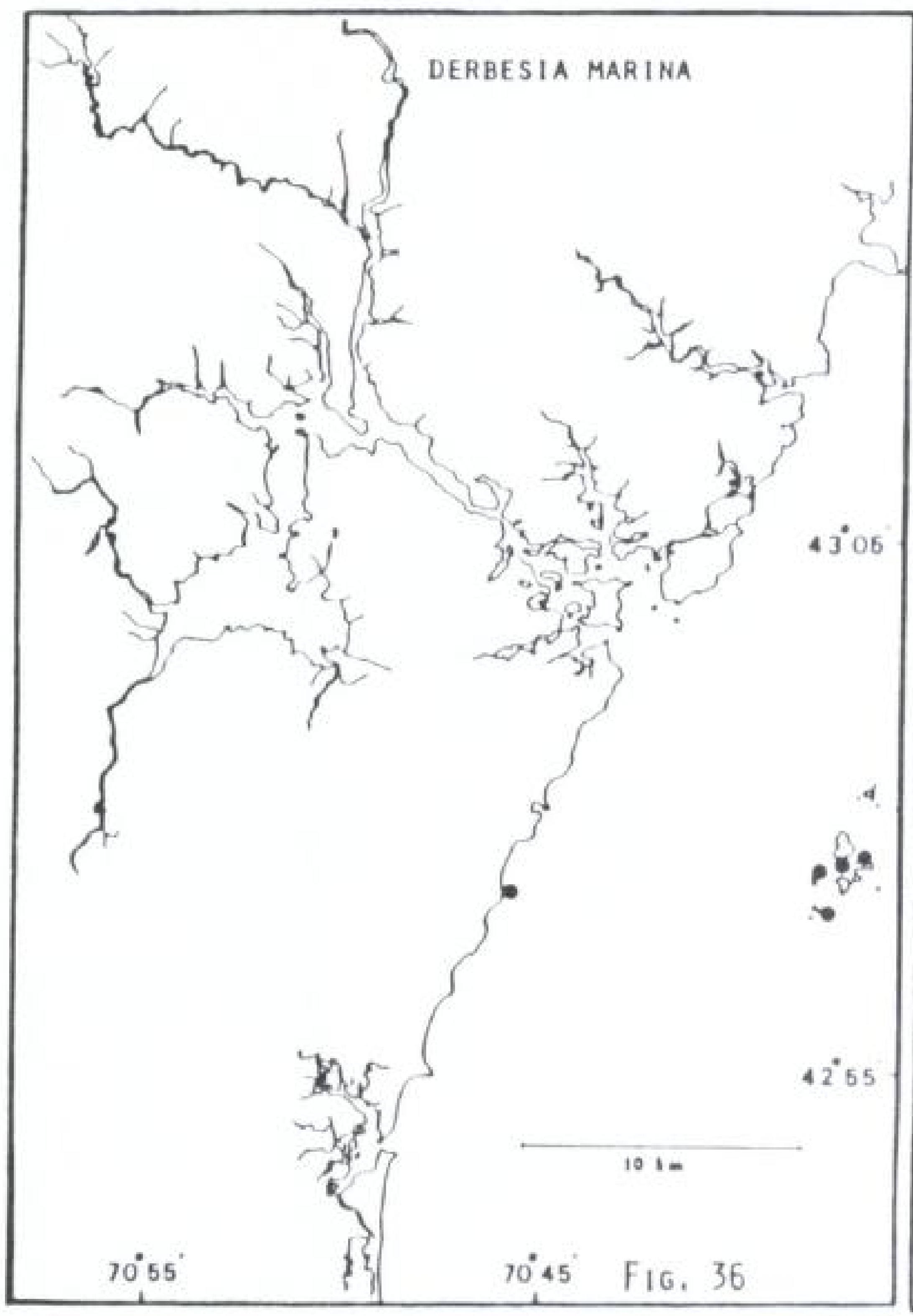


Fig. 36

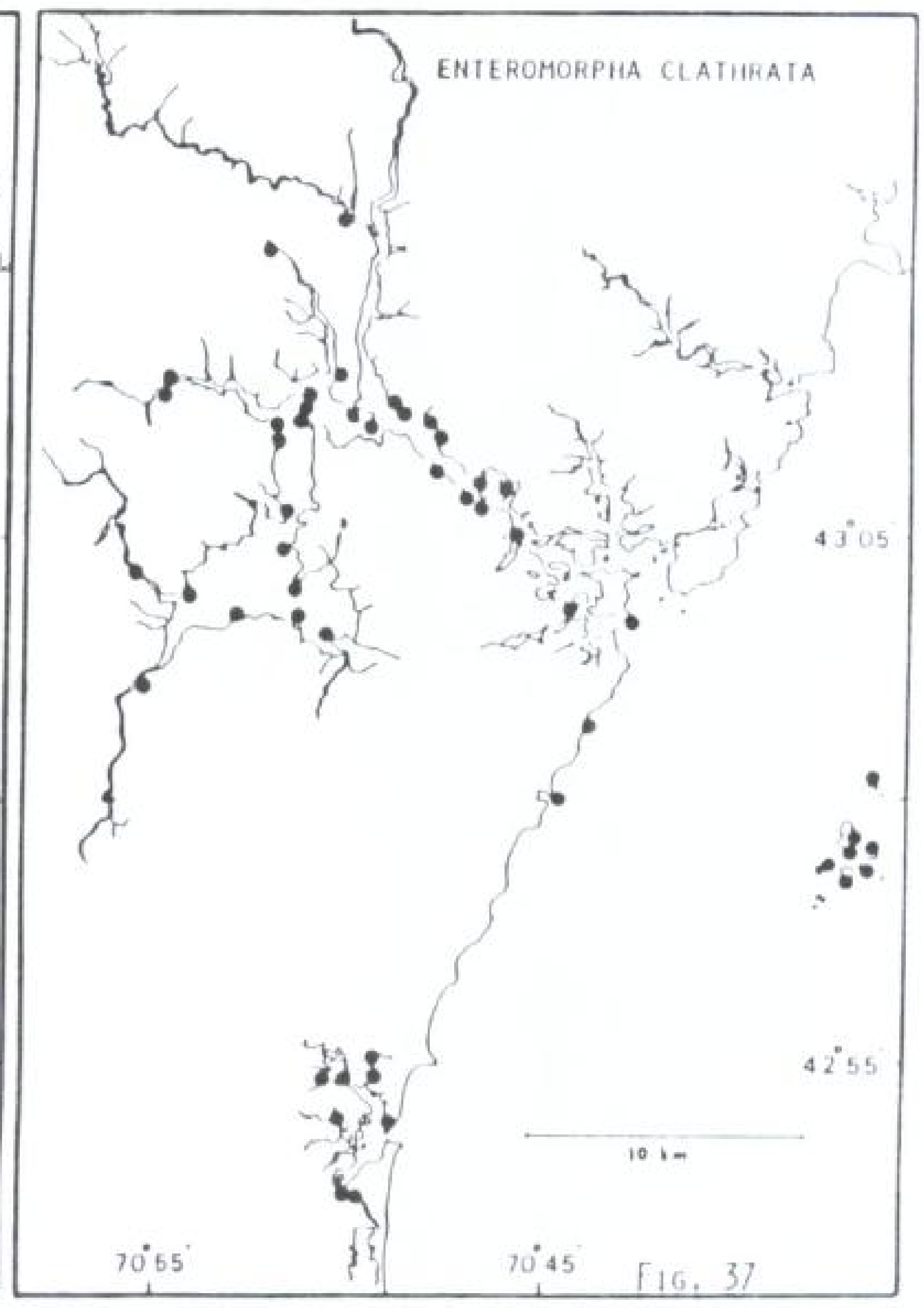


Fig. 37

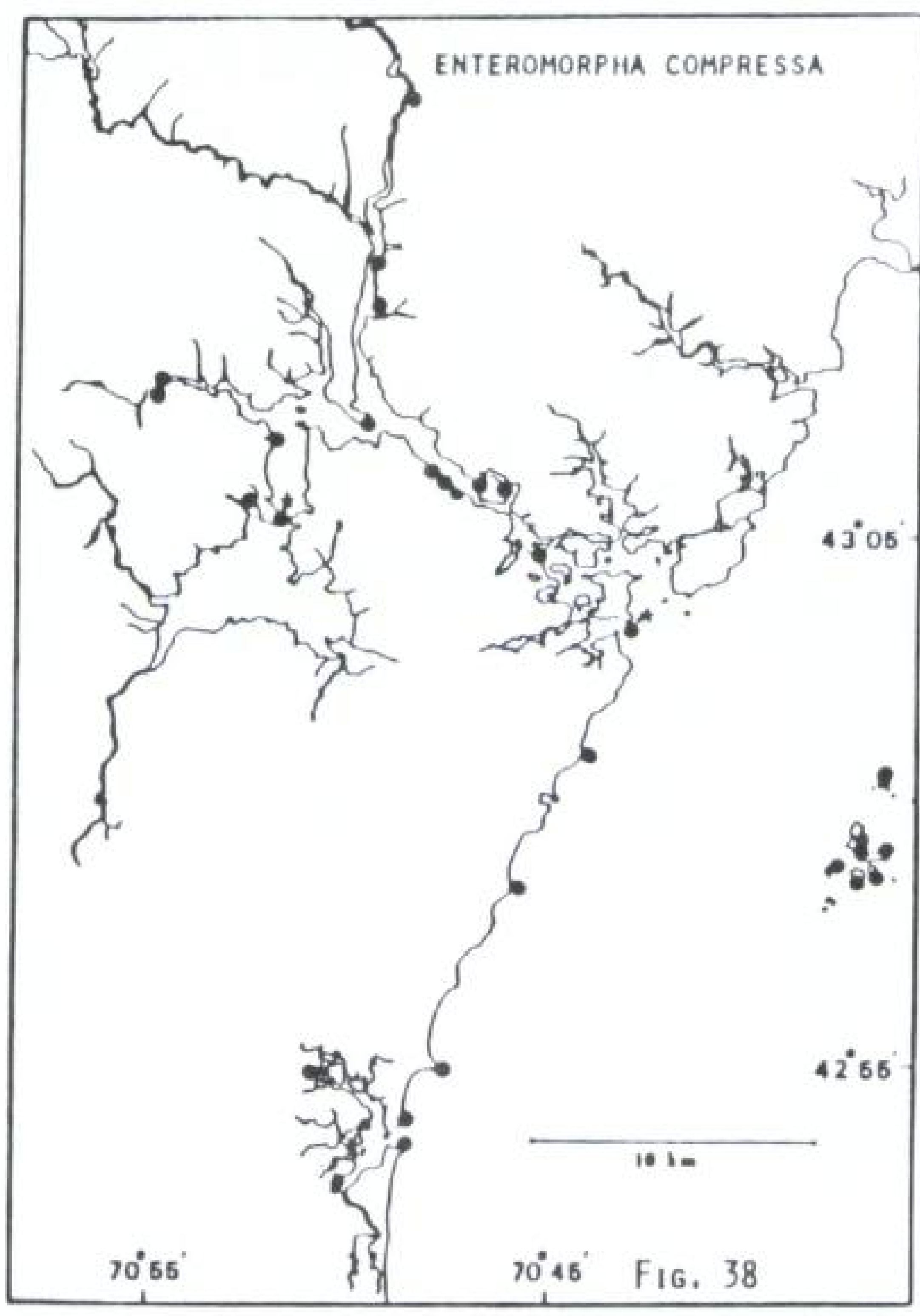


Fig. 38

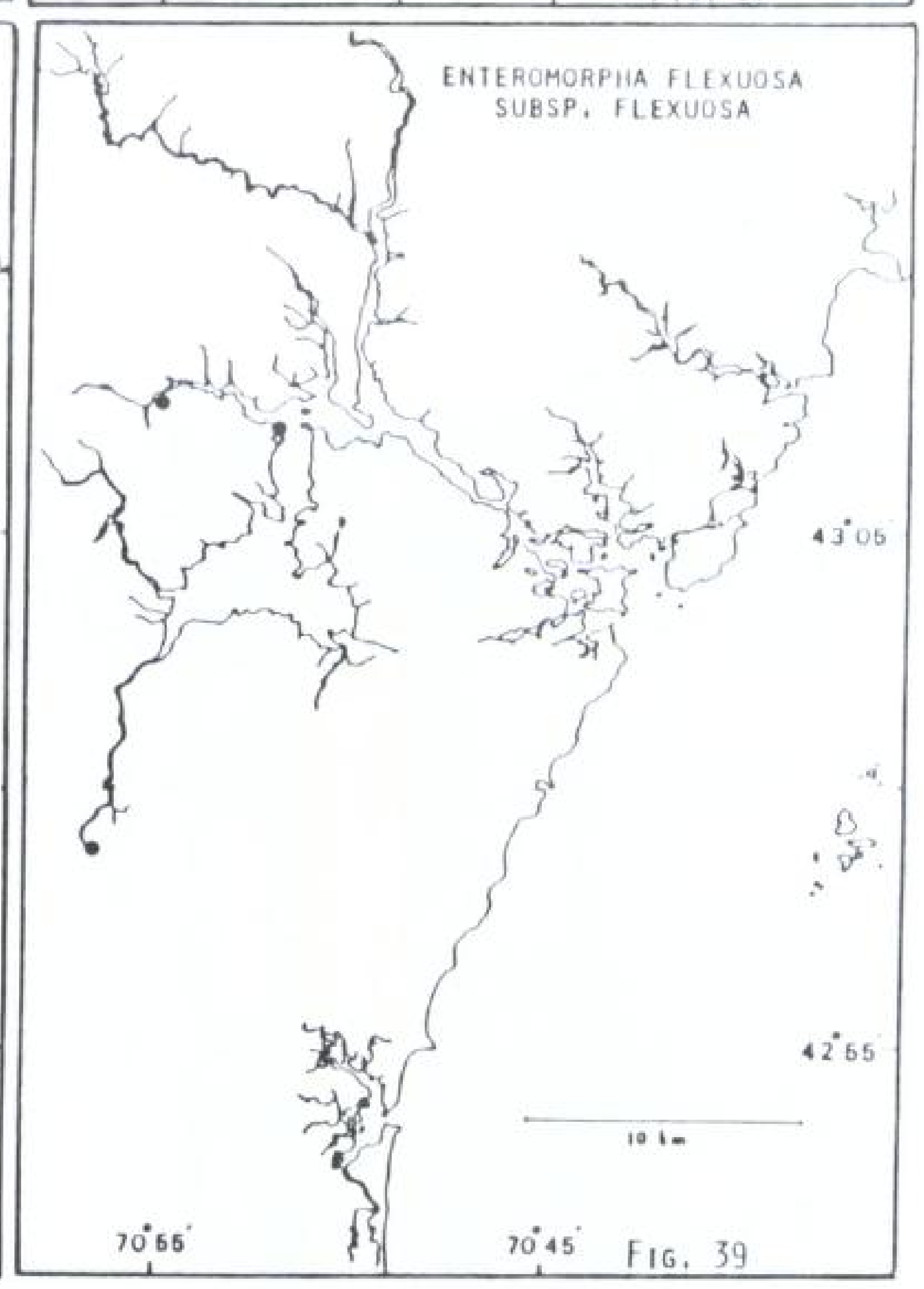


Fig. 39

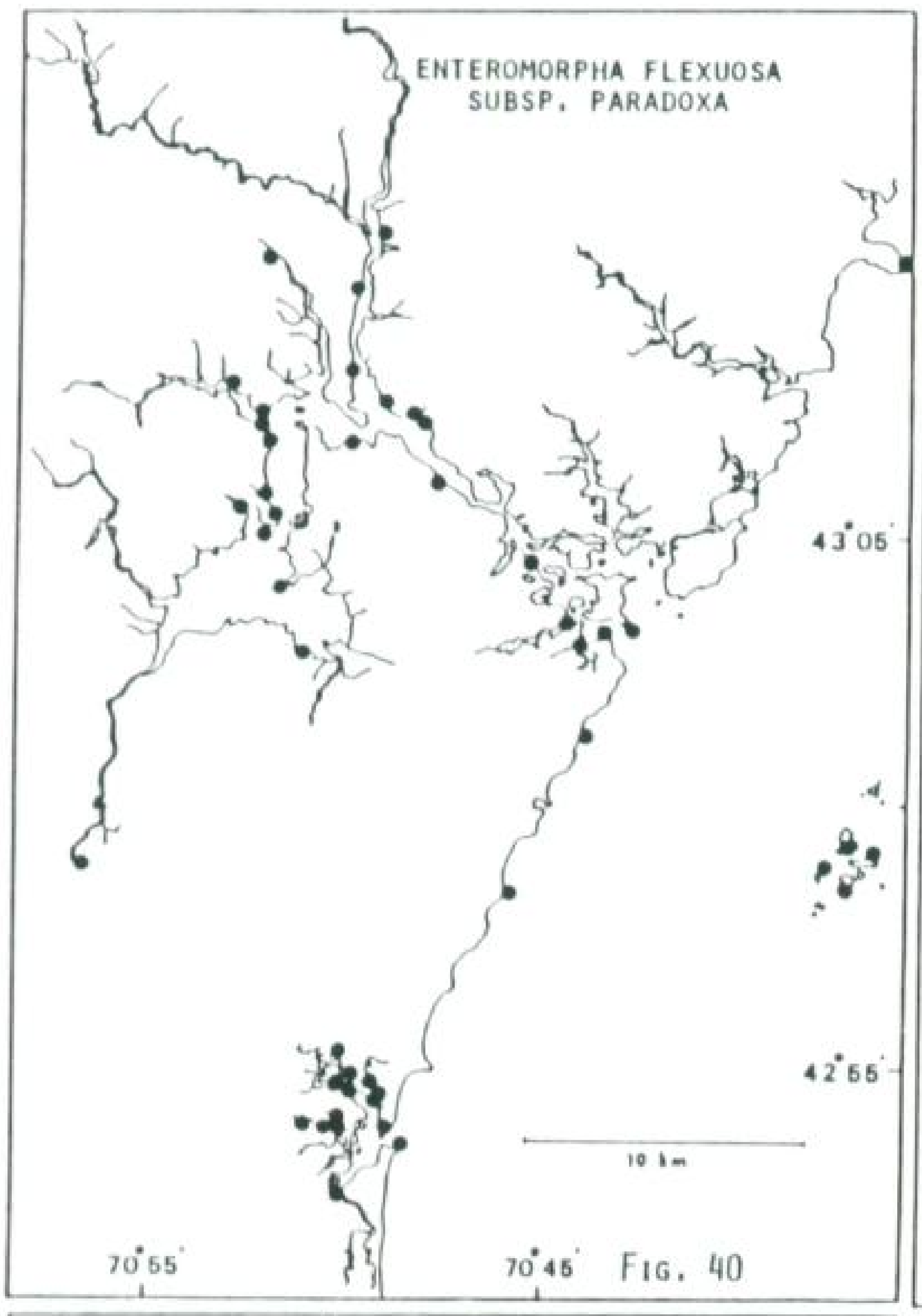


FIG. 40

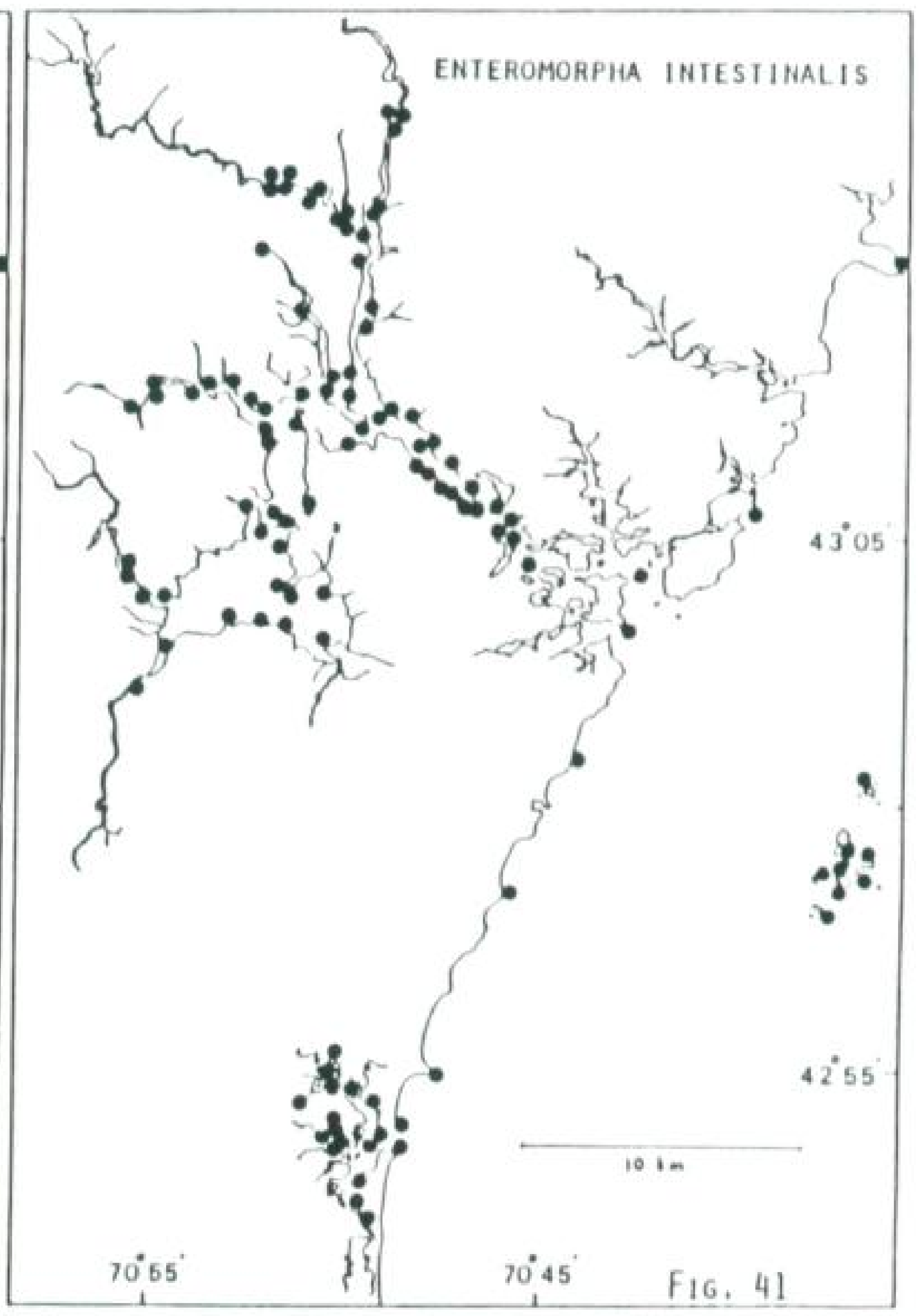


FIG. 41

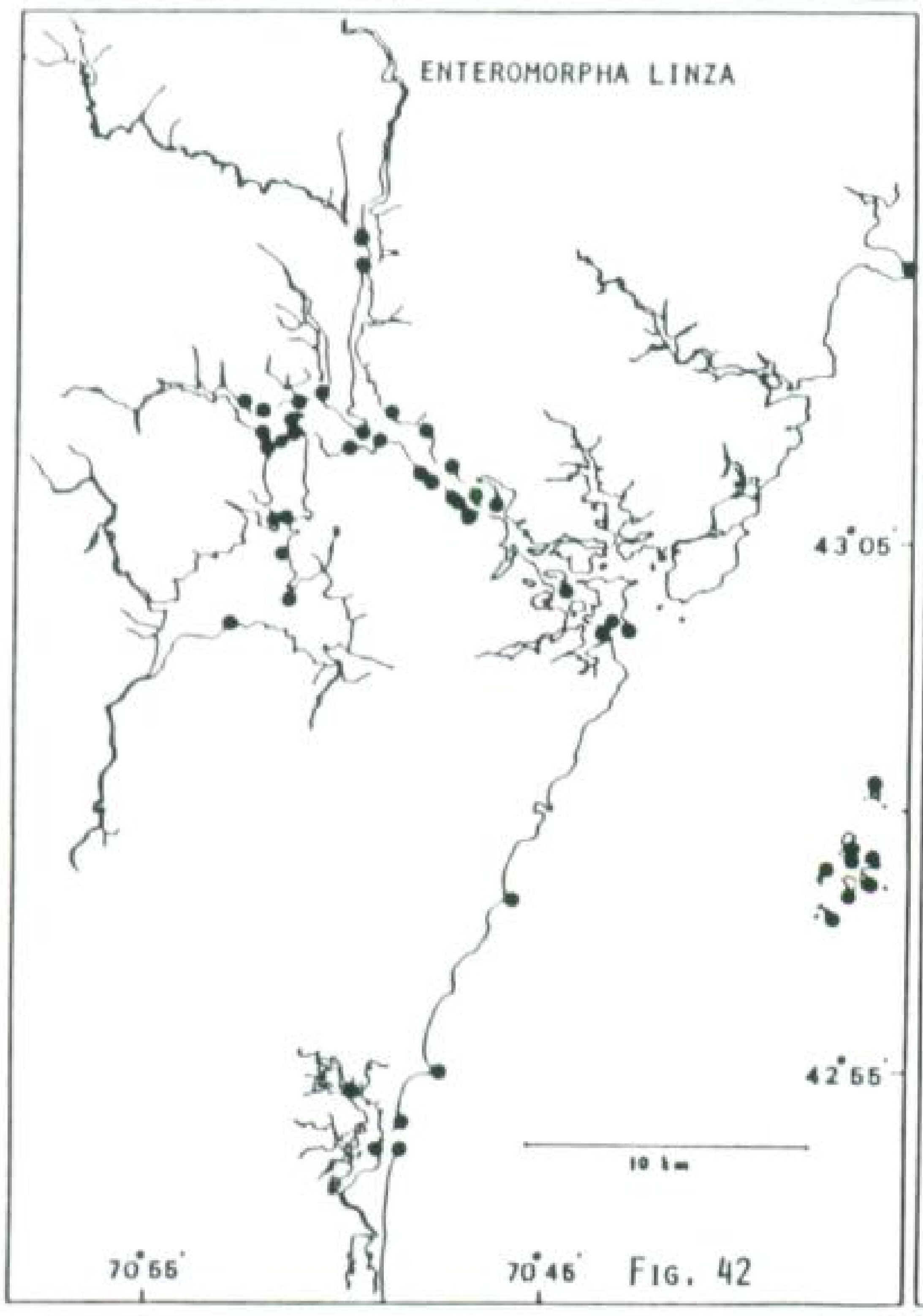


FIG. 42

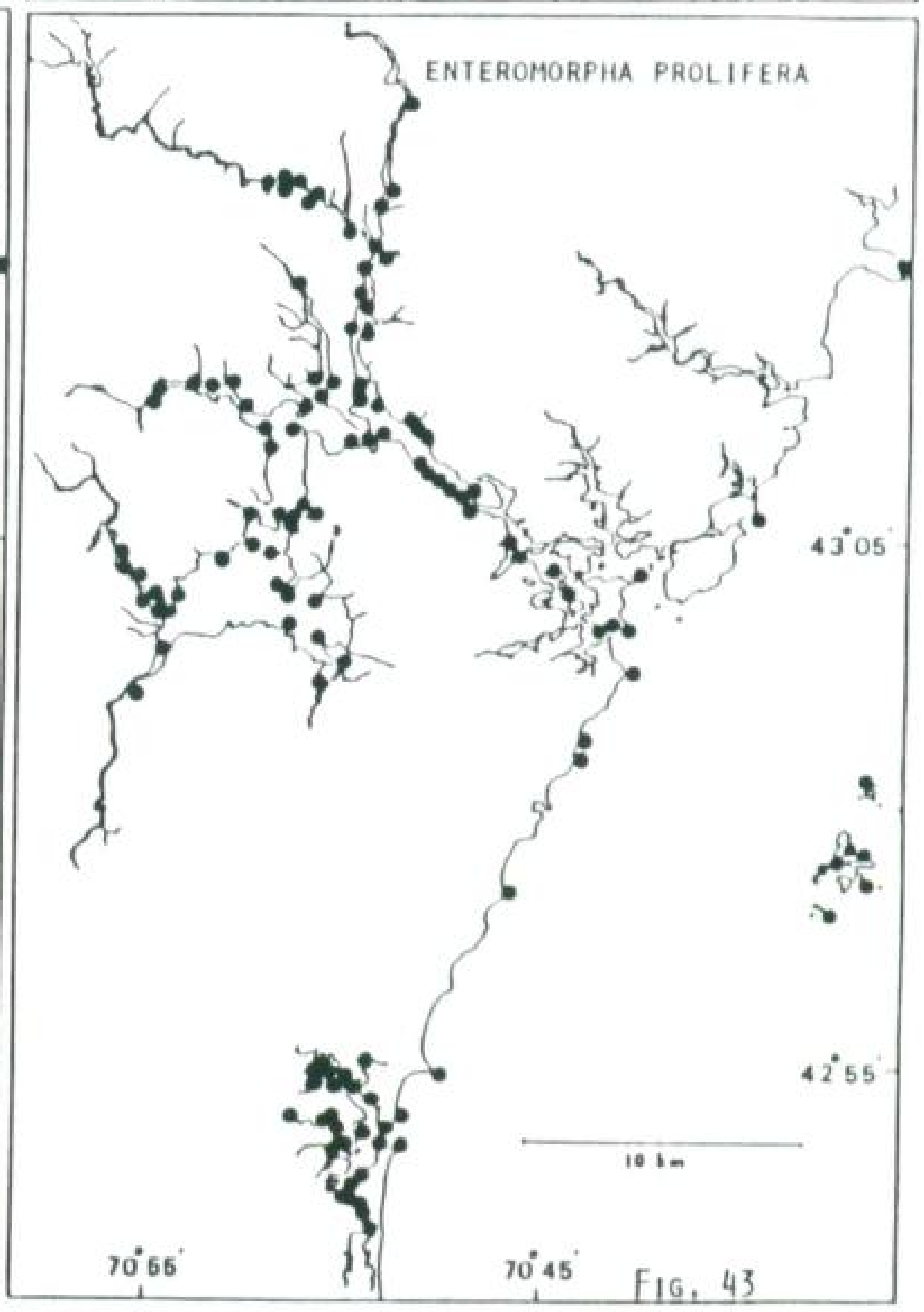


FIG. 43

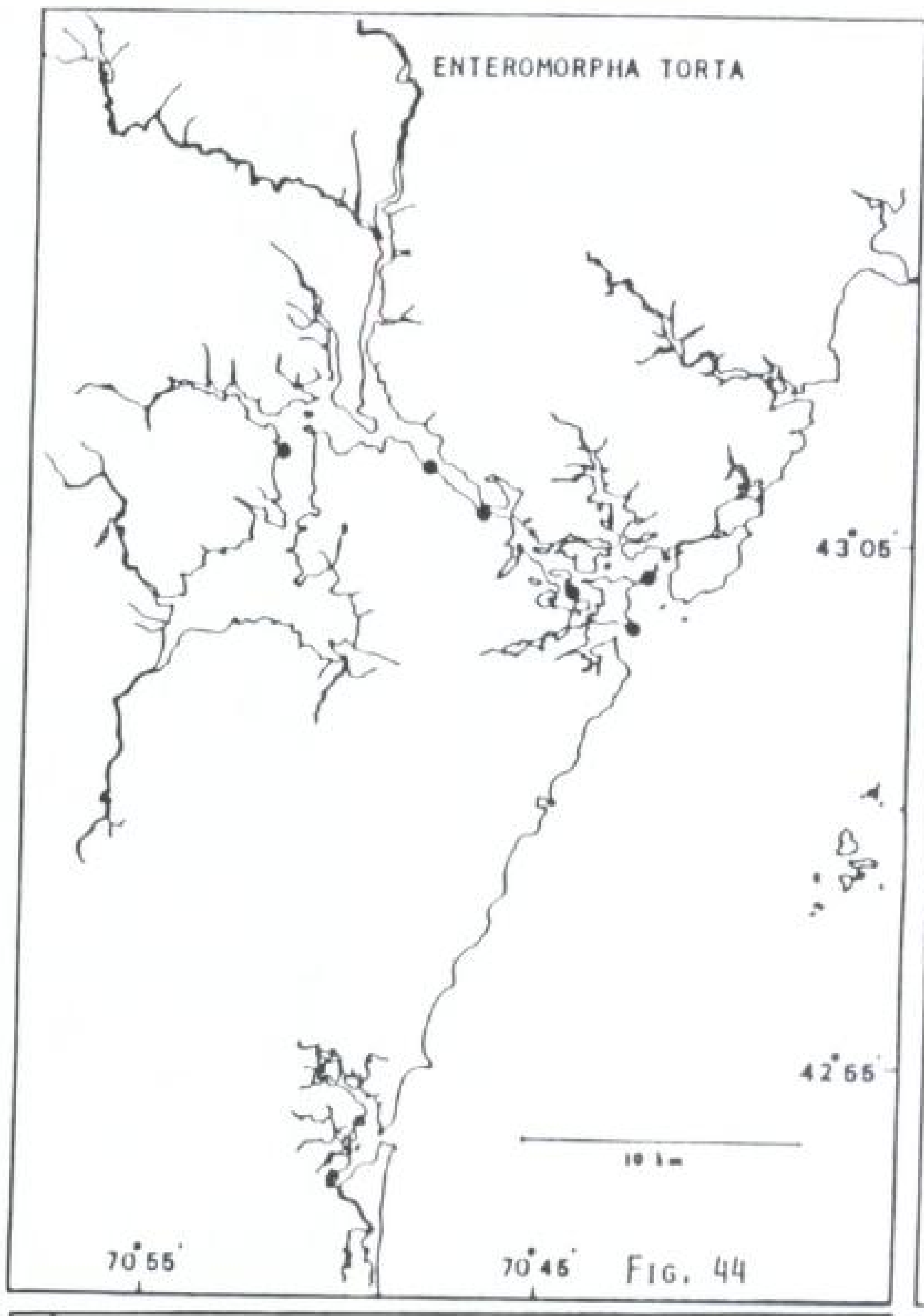


FIG. 44

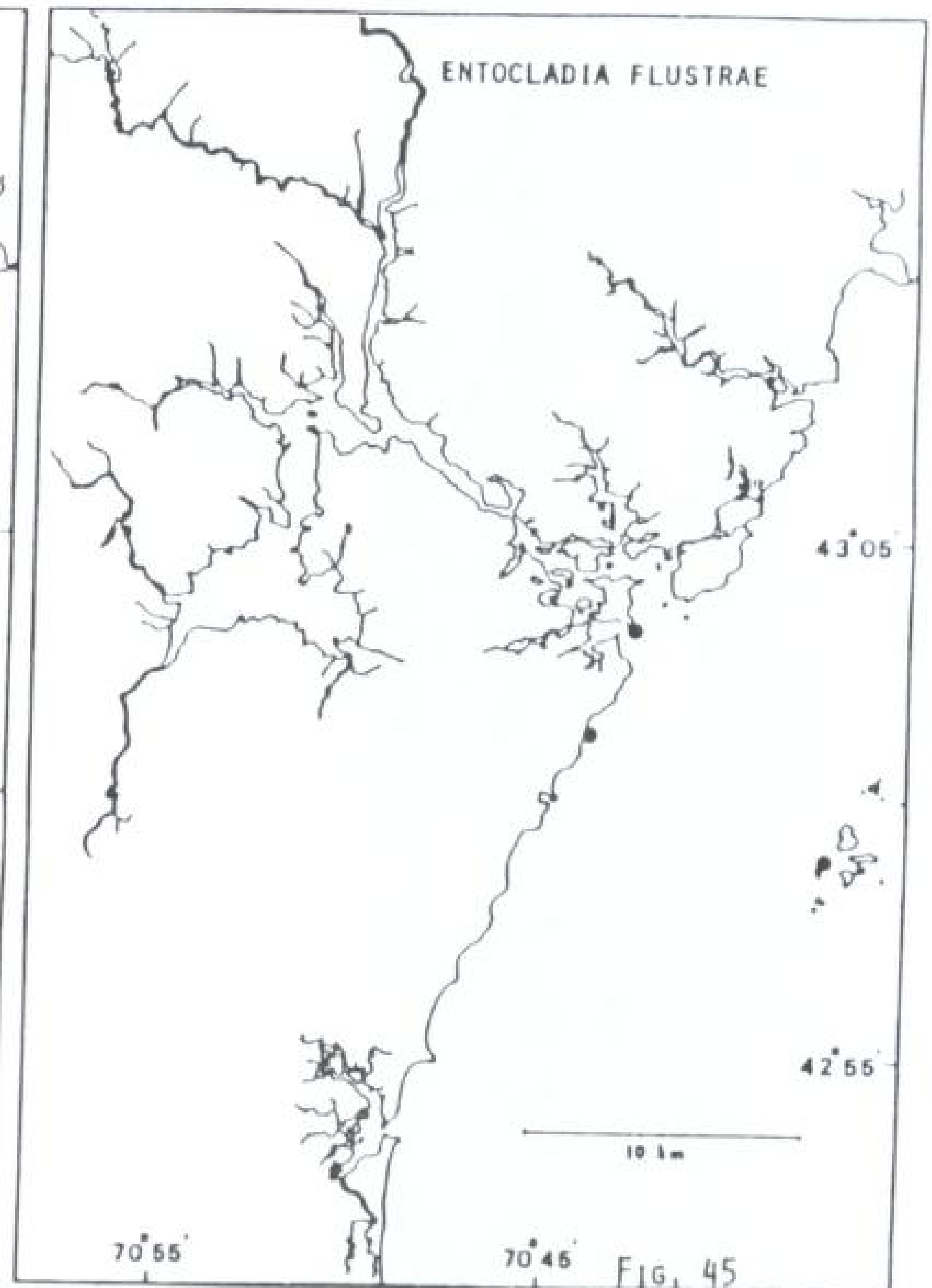


FIG. 45

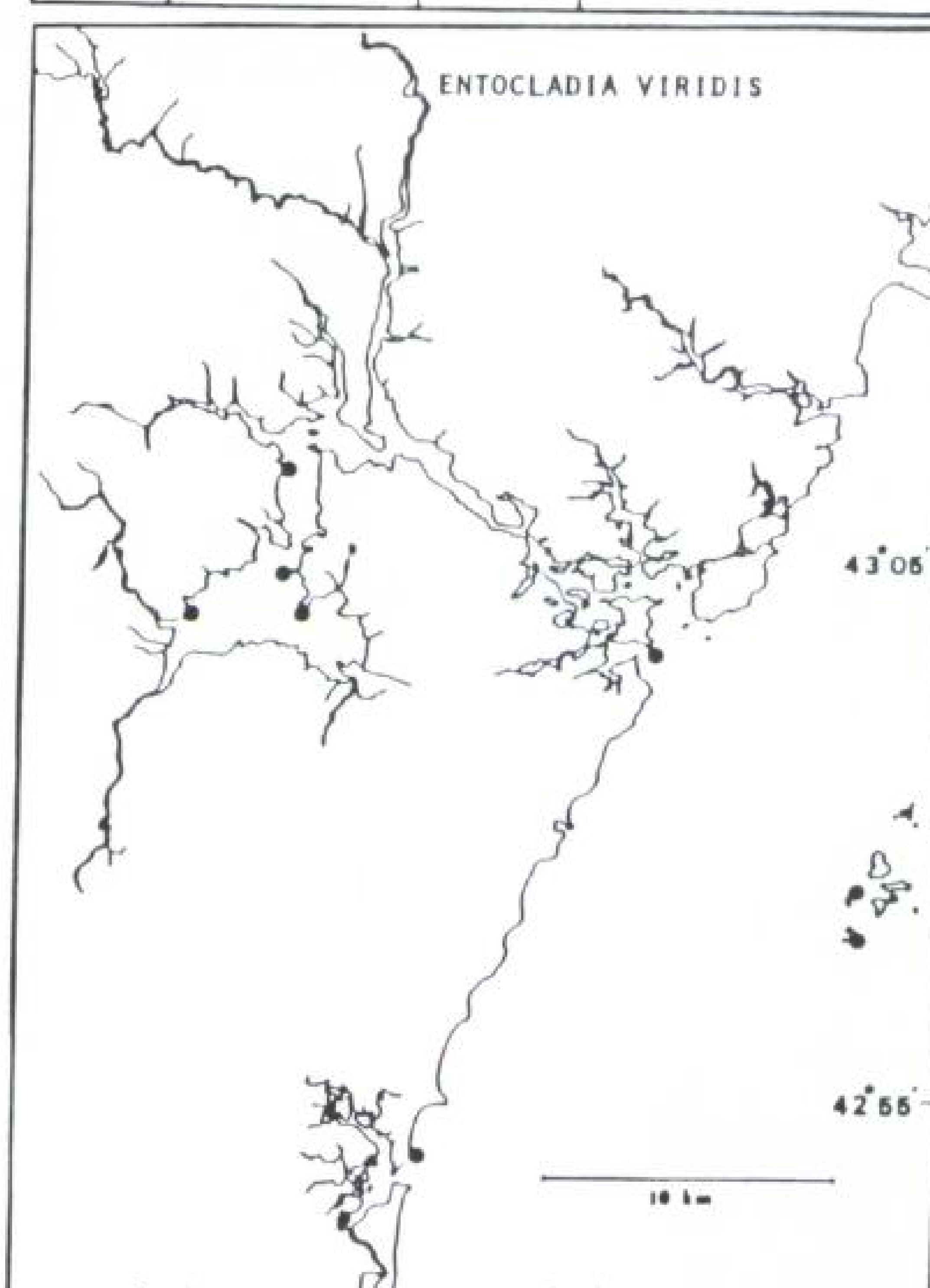


FIG. 46

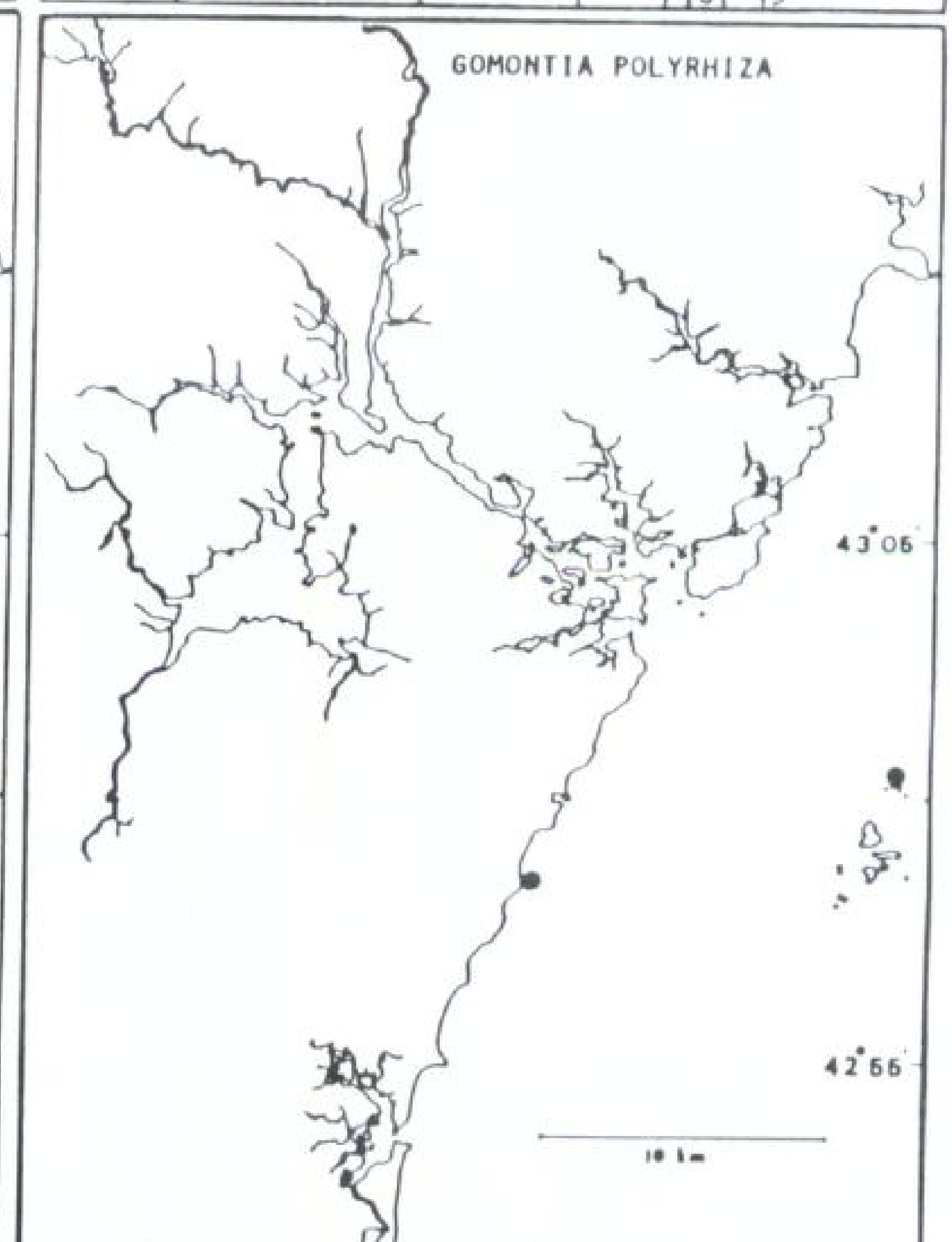


FIG. 47

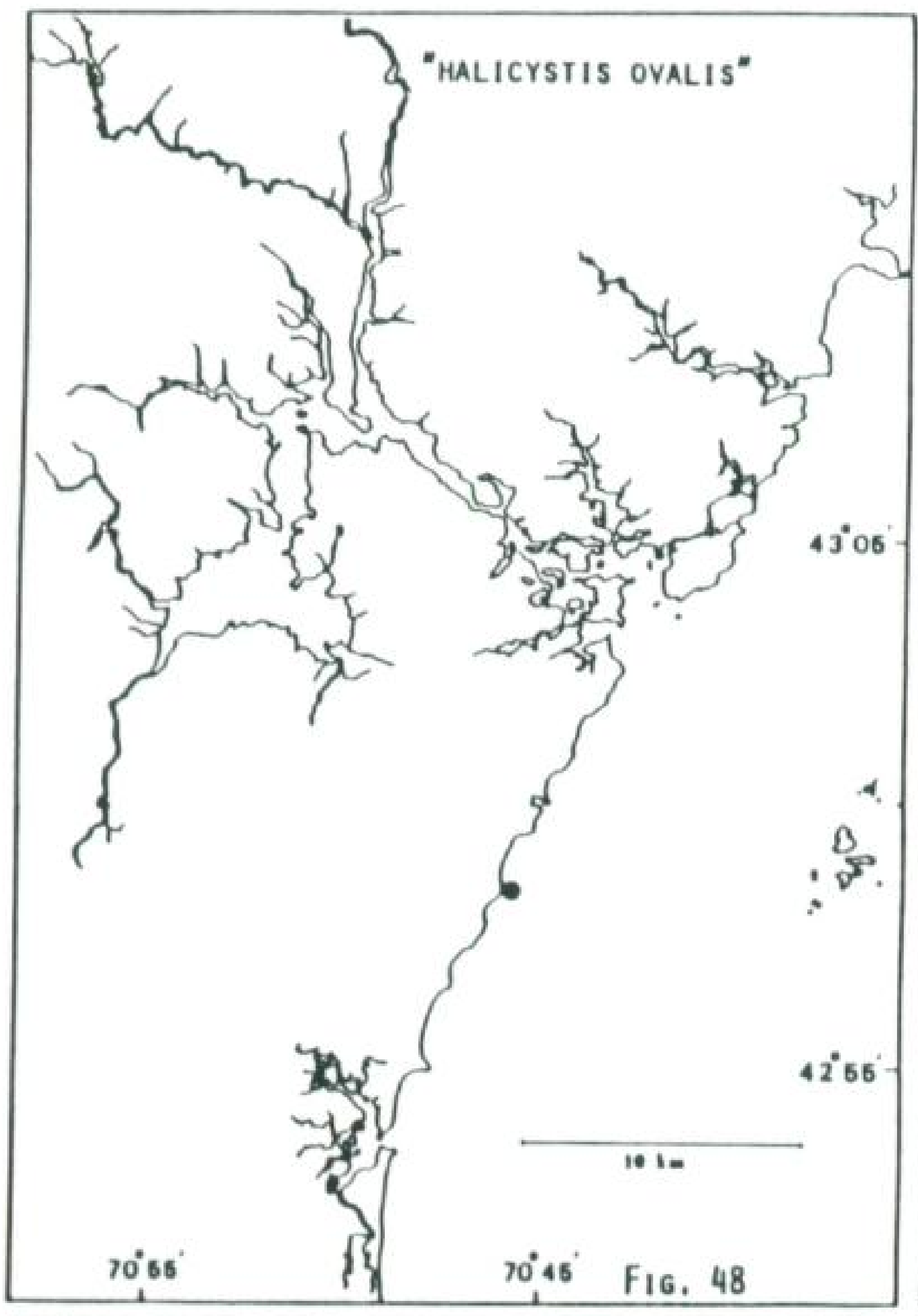


FIG. 48

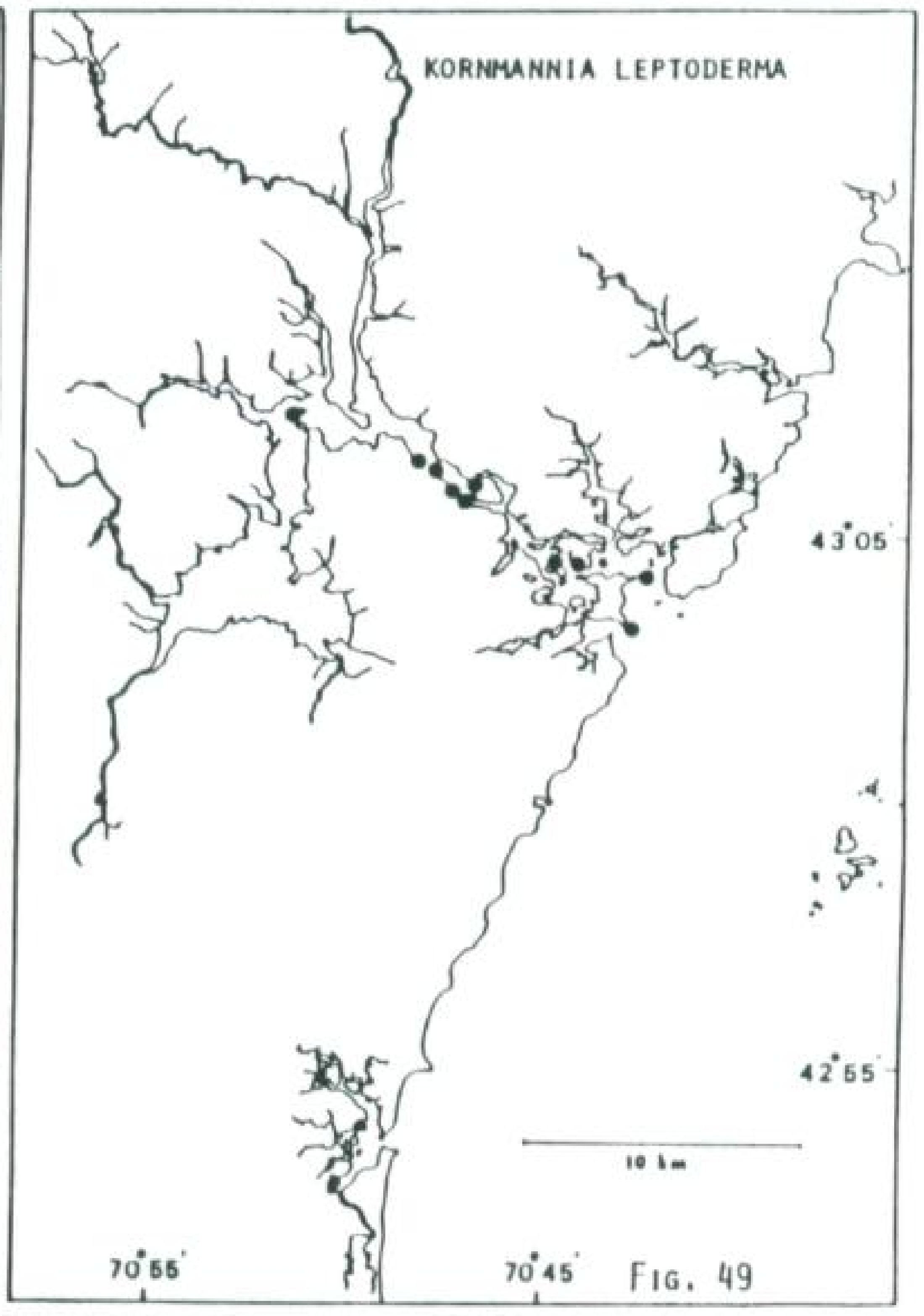


FIG. 49

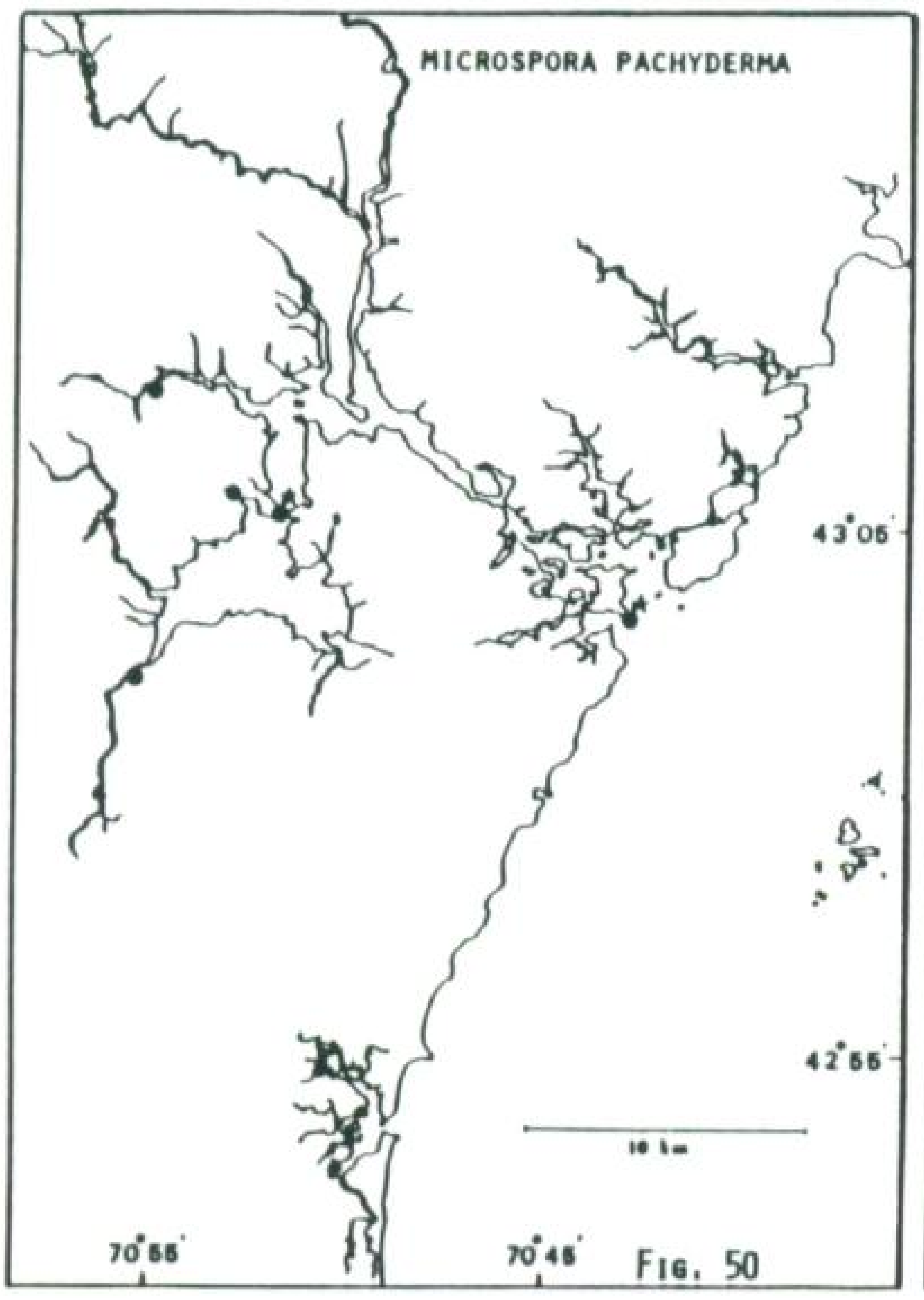


FIG. 50

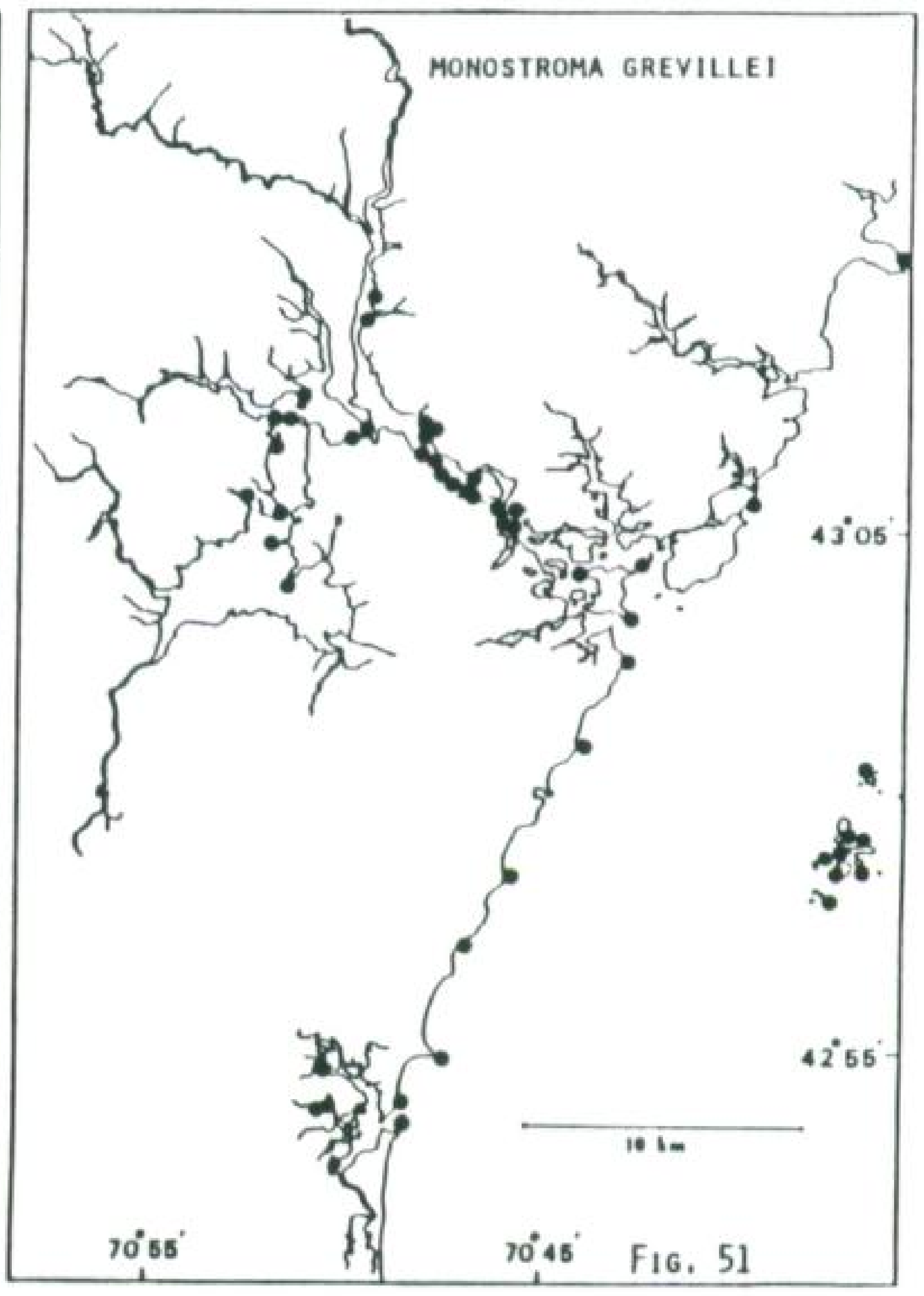


FIG. 51

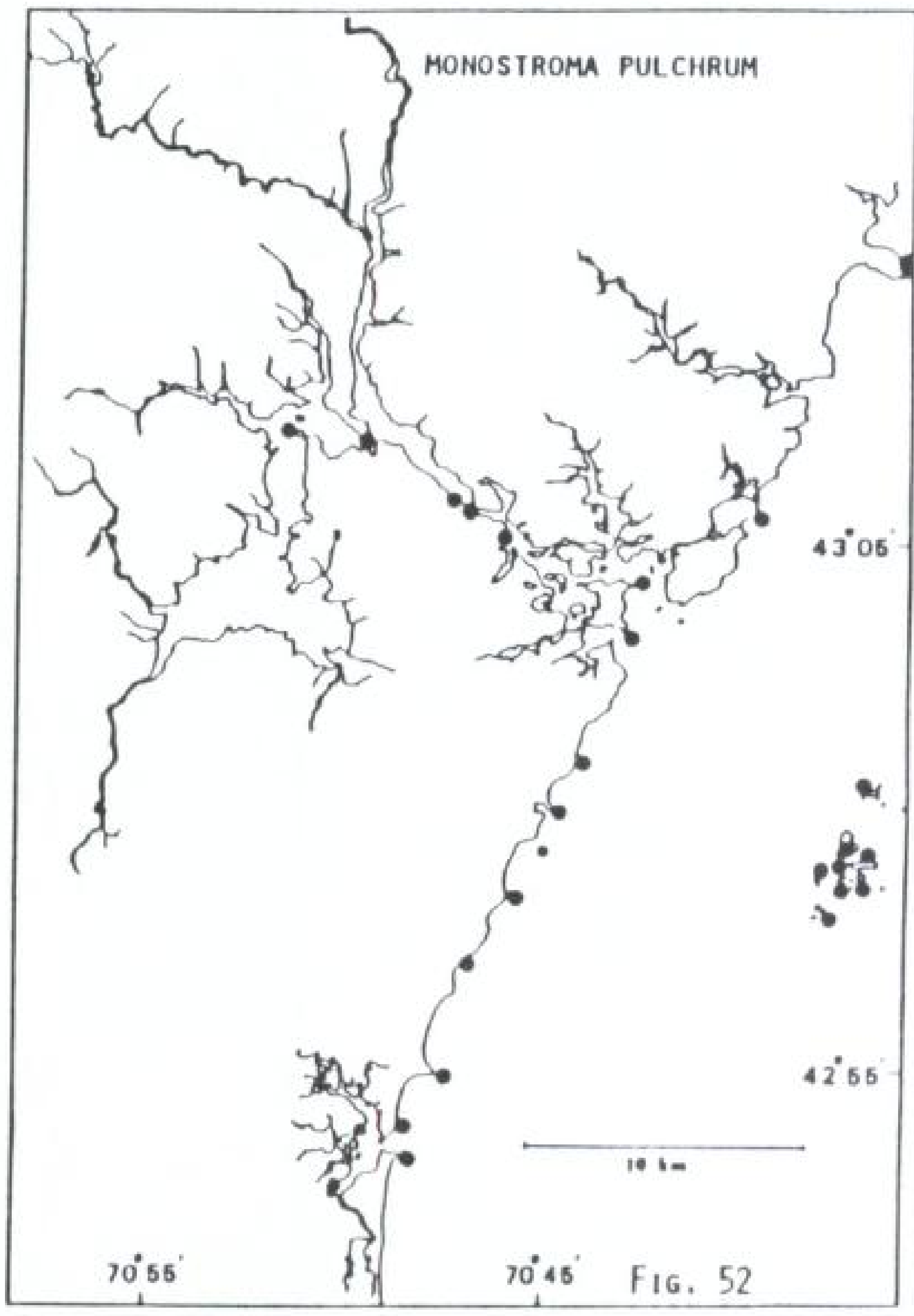


FIG. 52

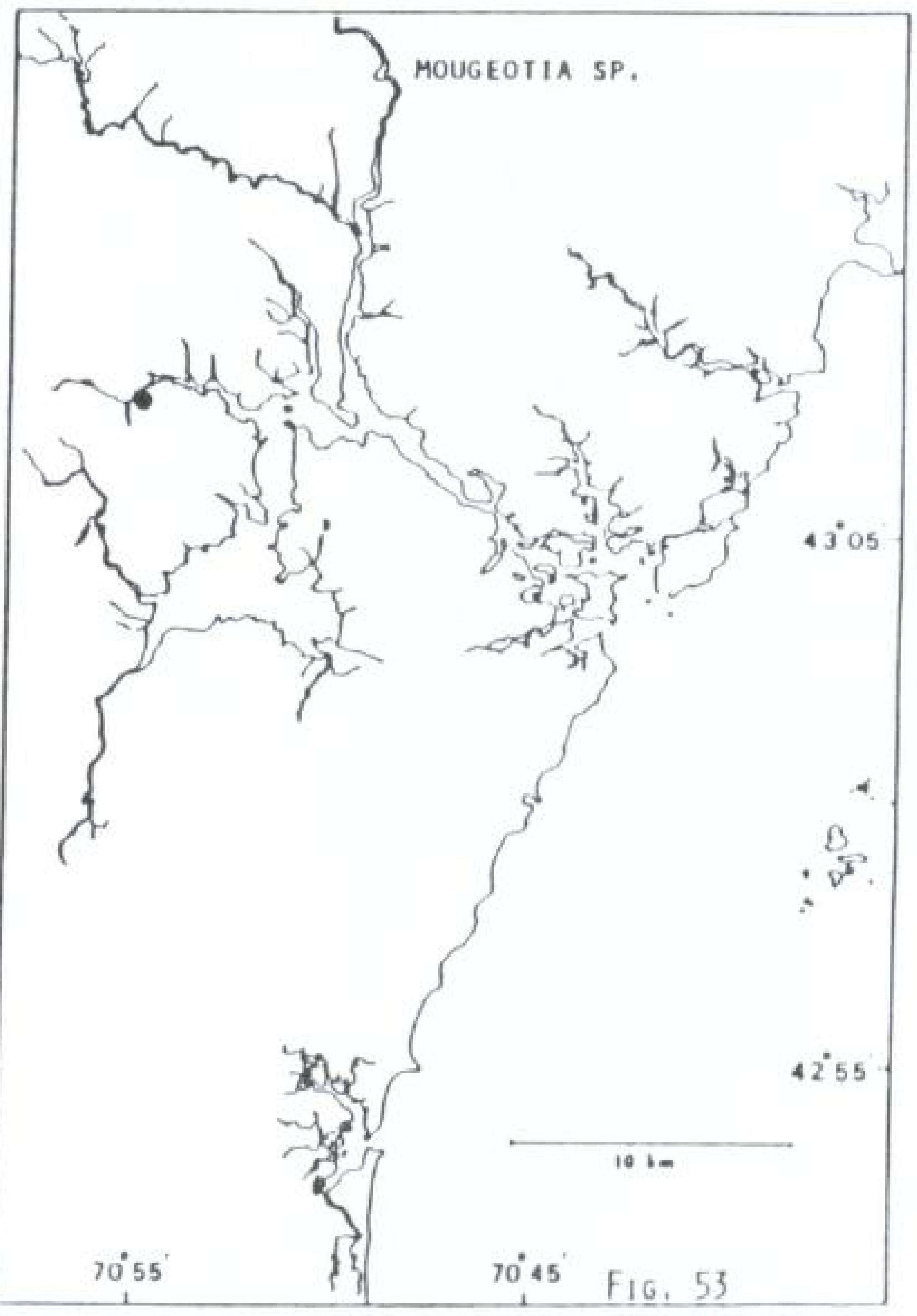


FIG. 53

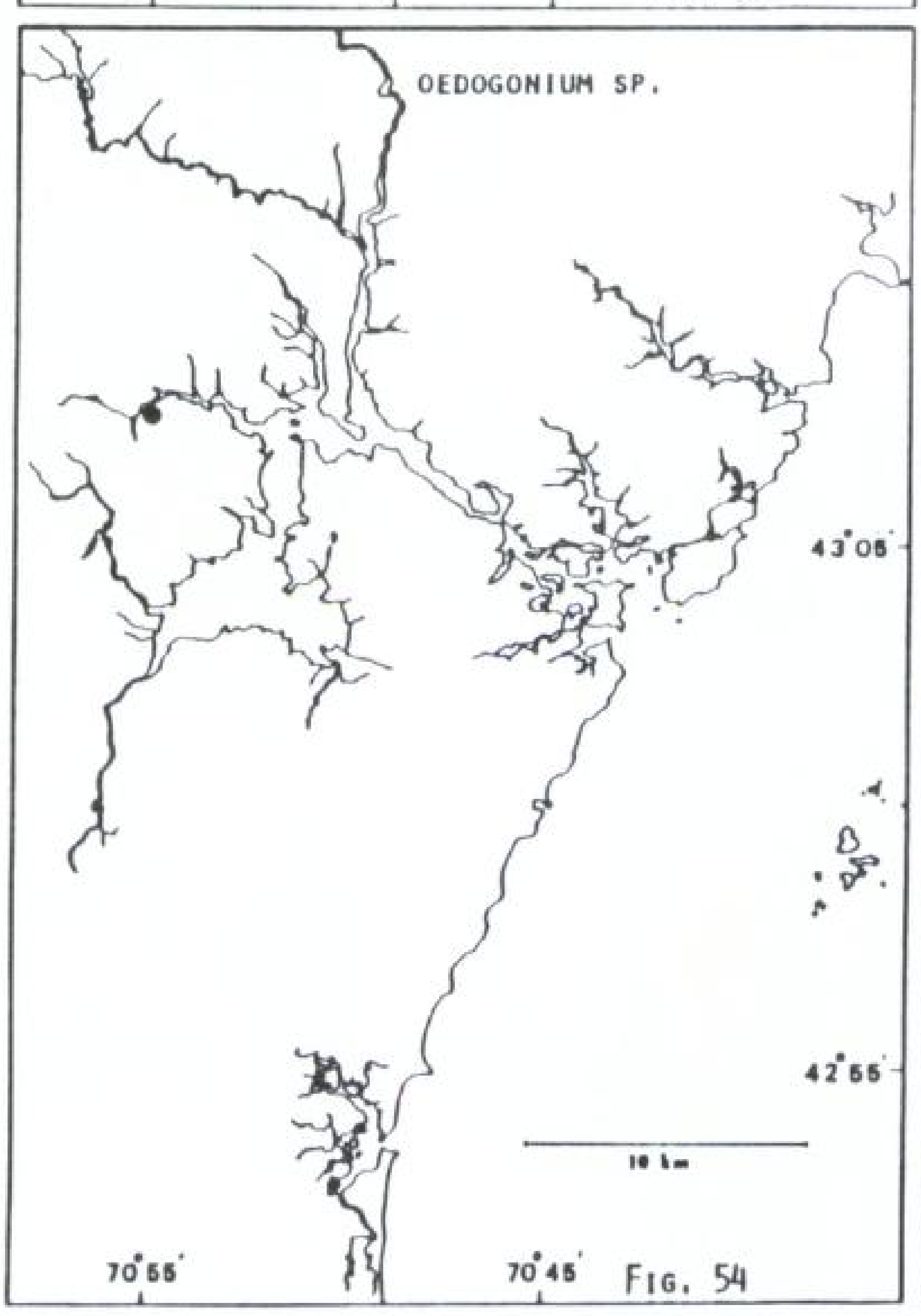


FIG. 54

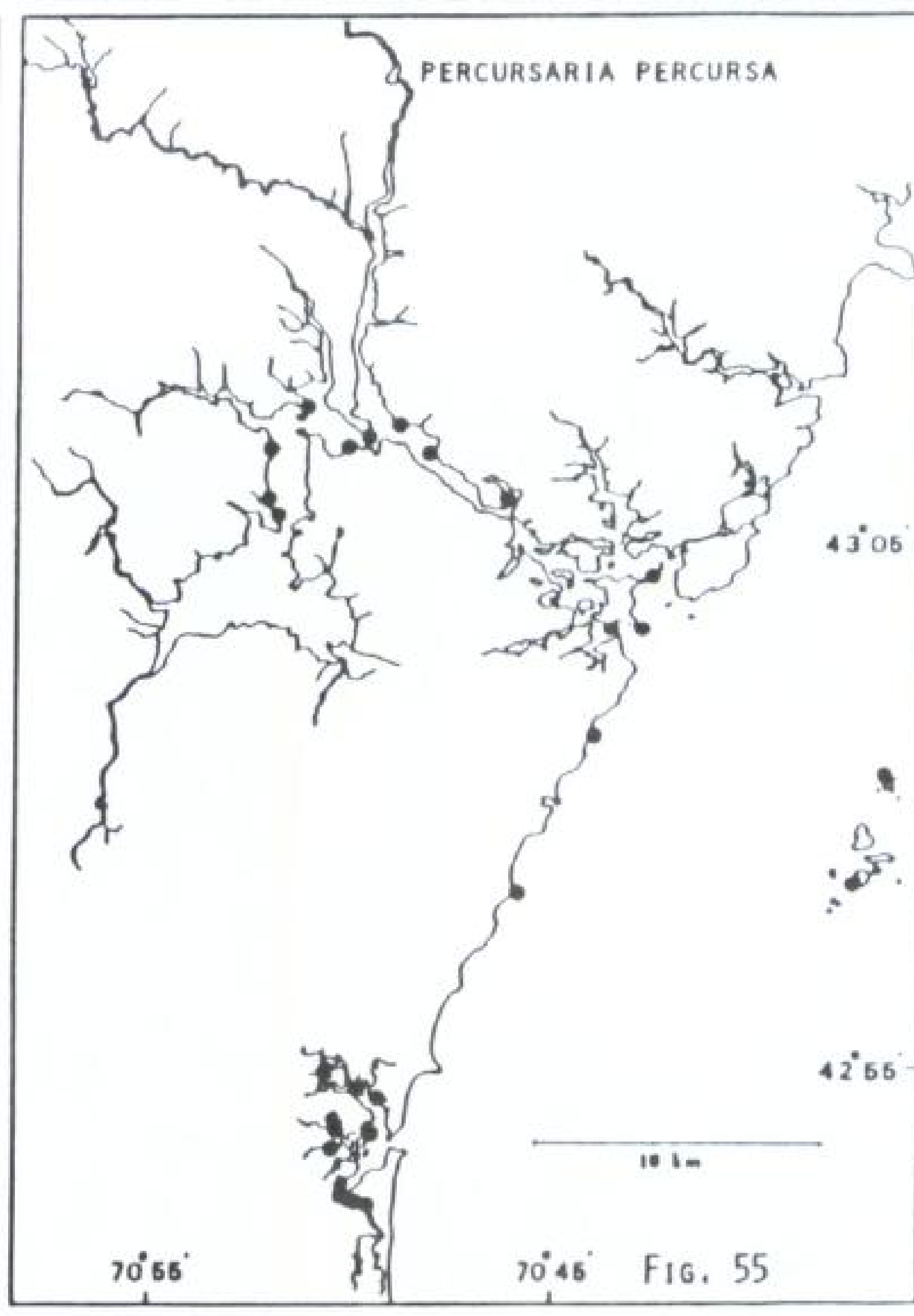


FIG. 55

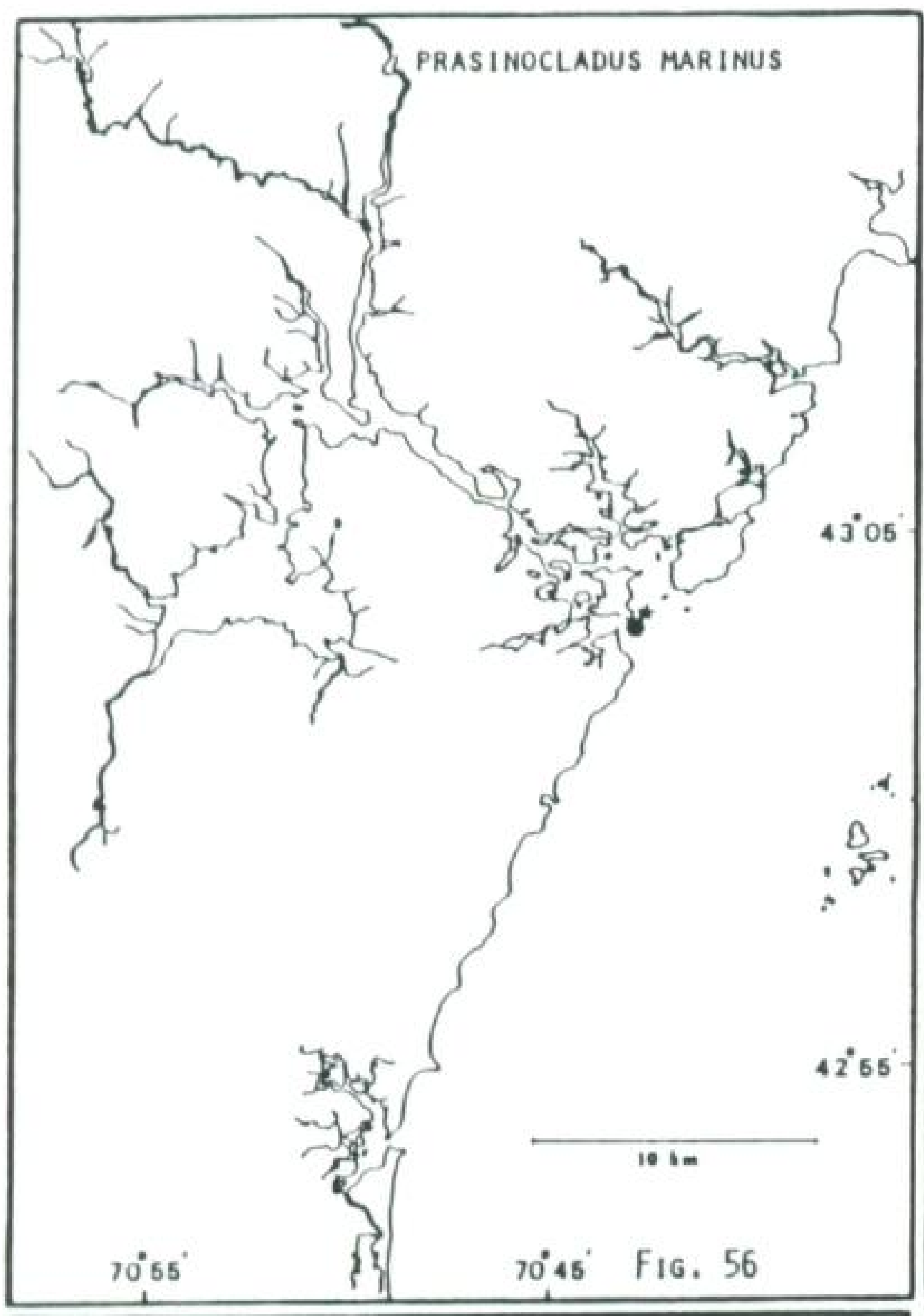


FIG. 56

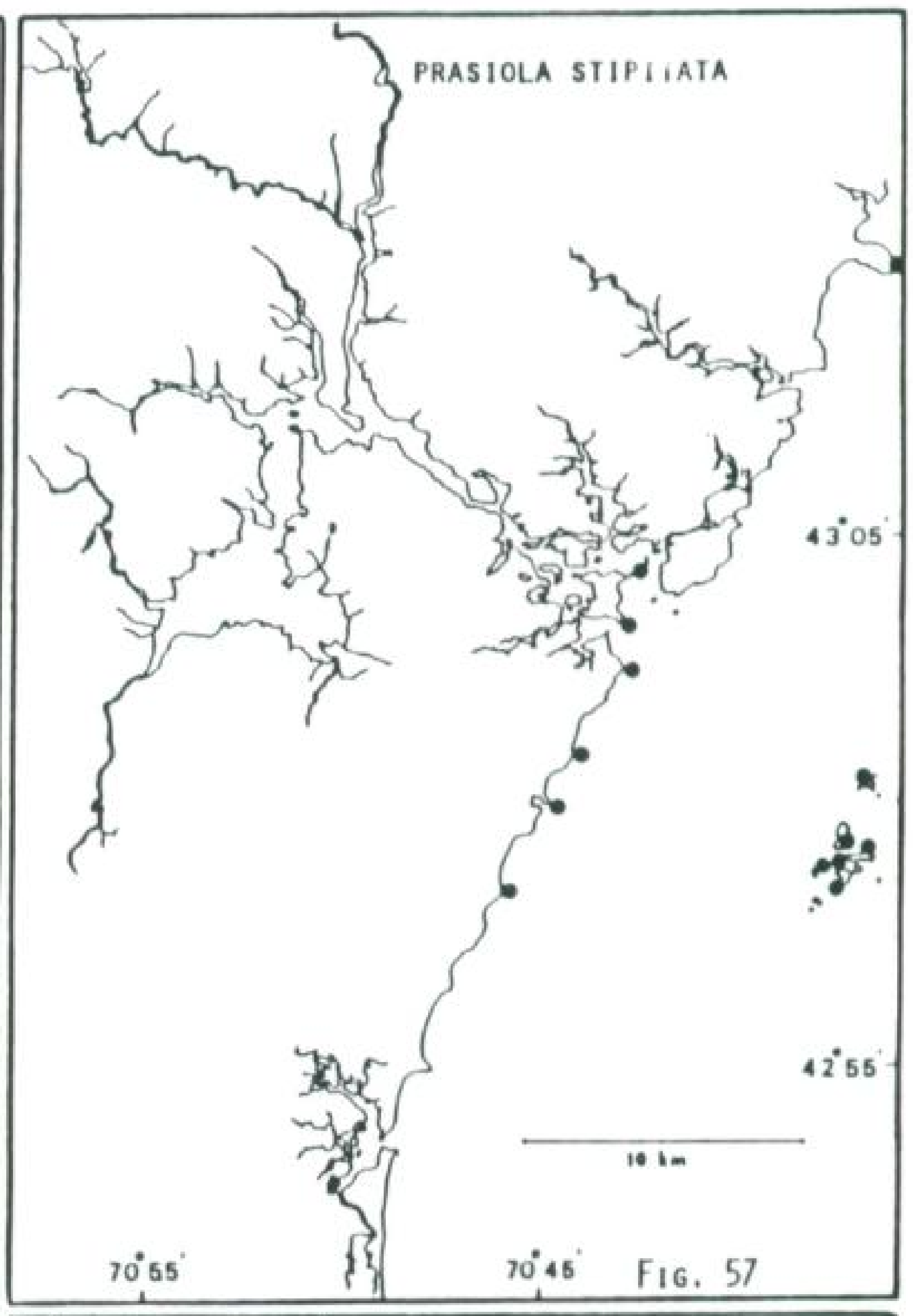


FIG. 57

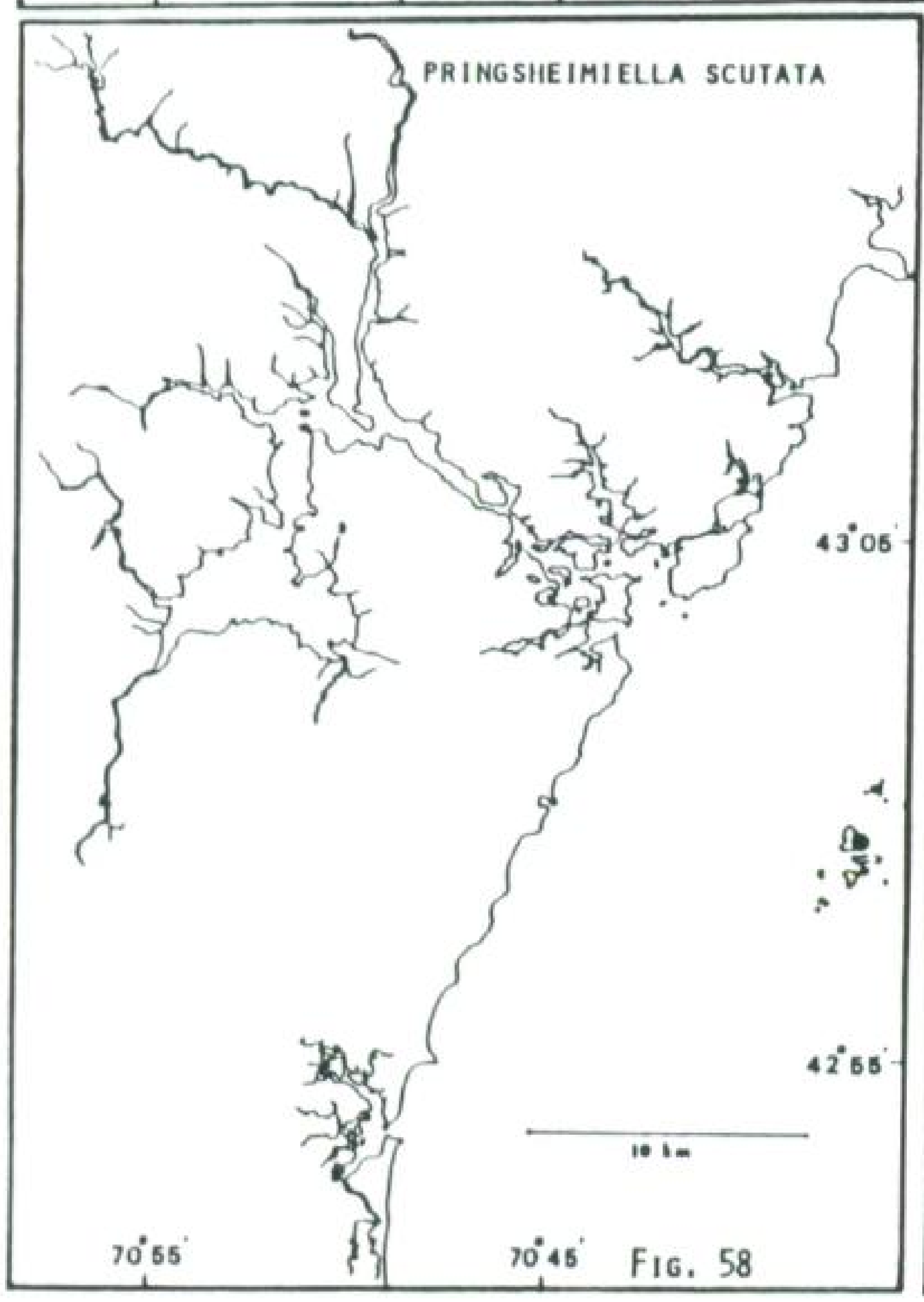


FIG. 58

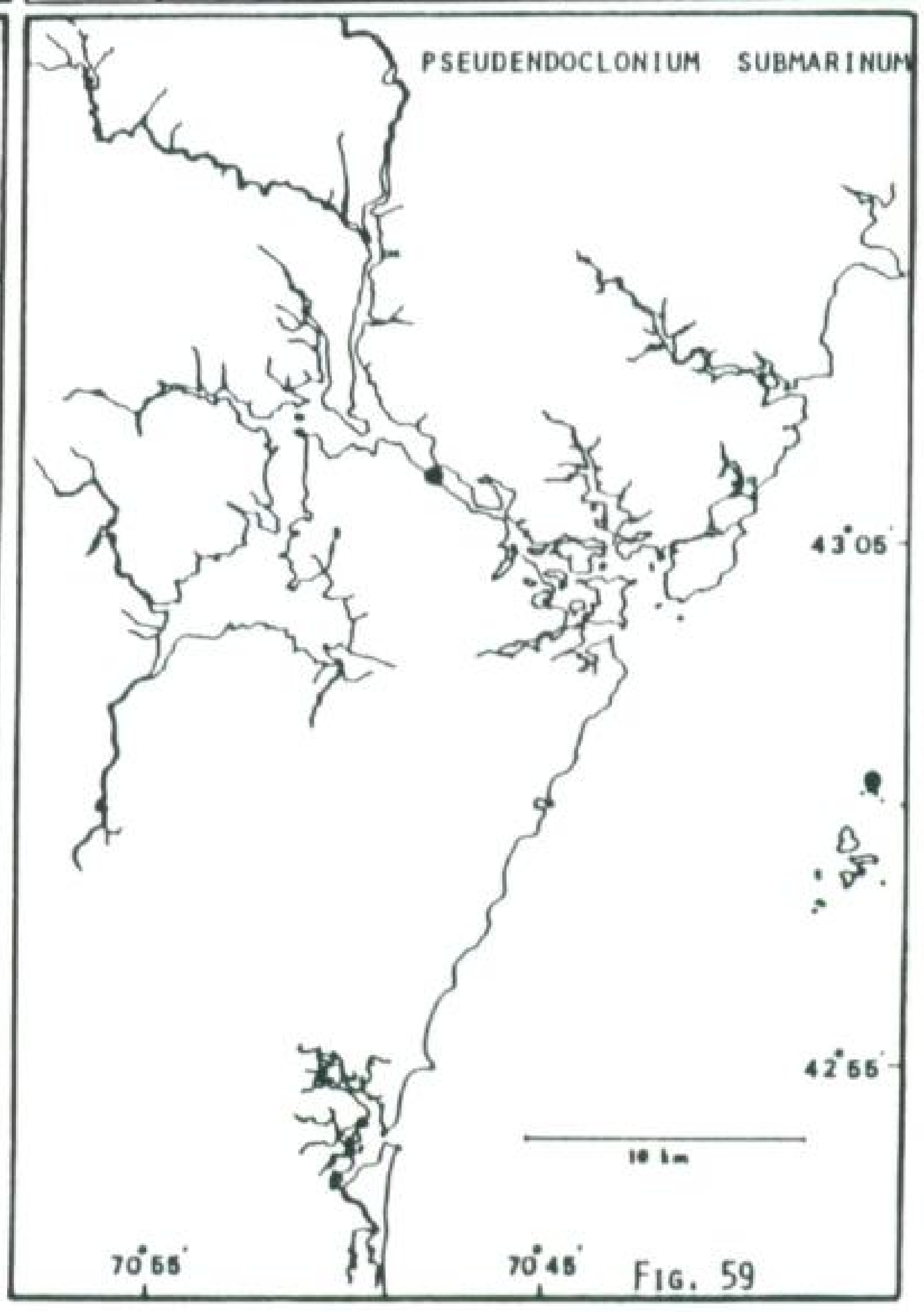


FIG. 59

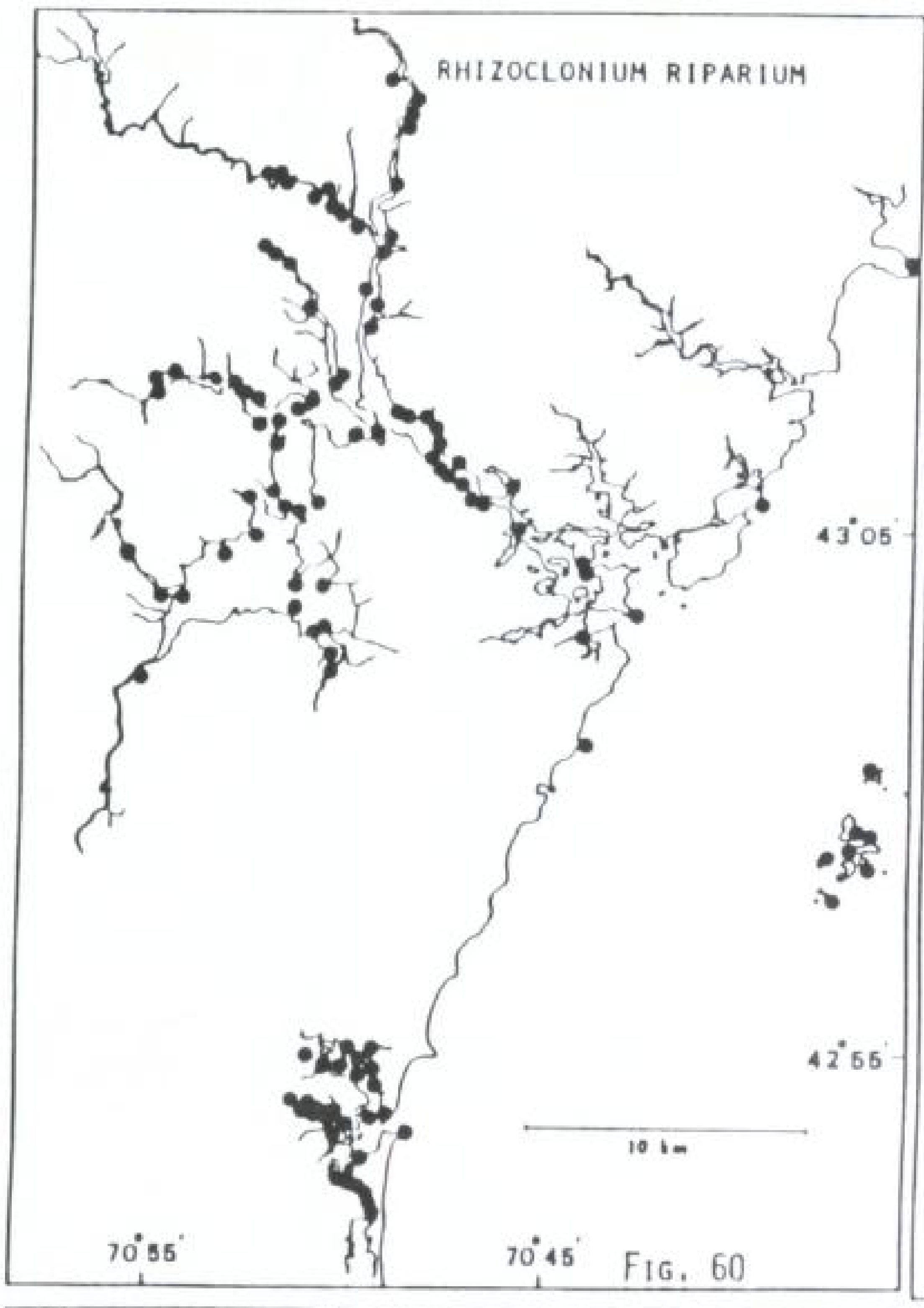


Fig. 60

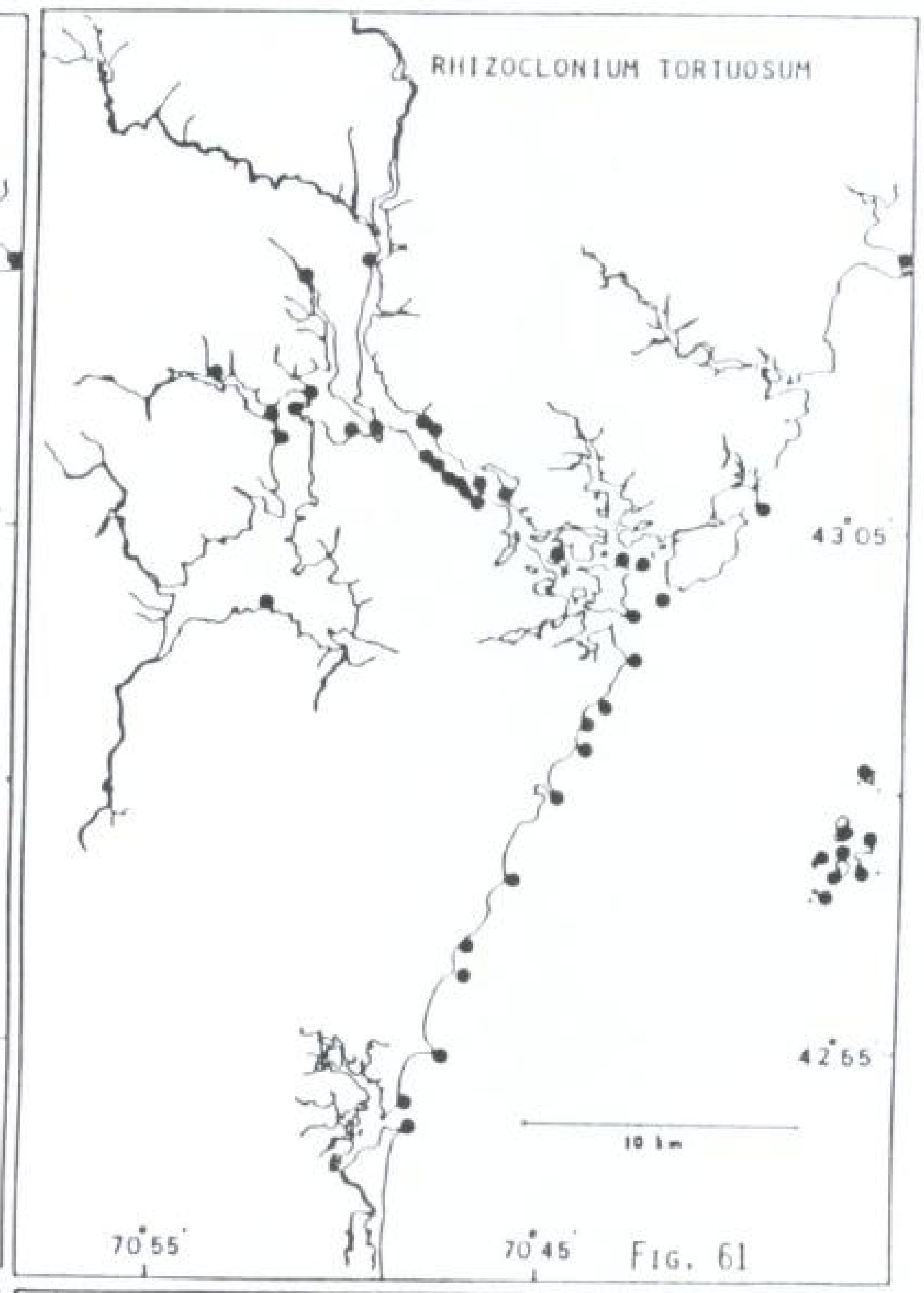


Fig. 61

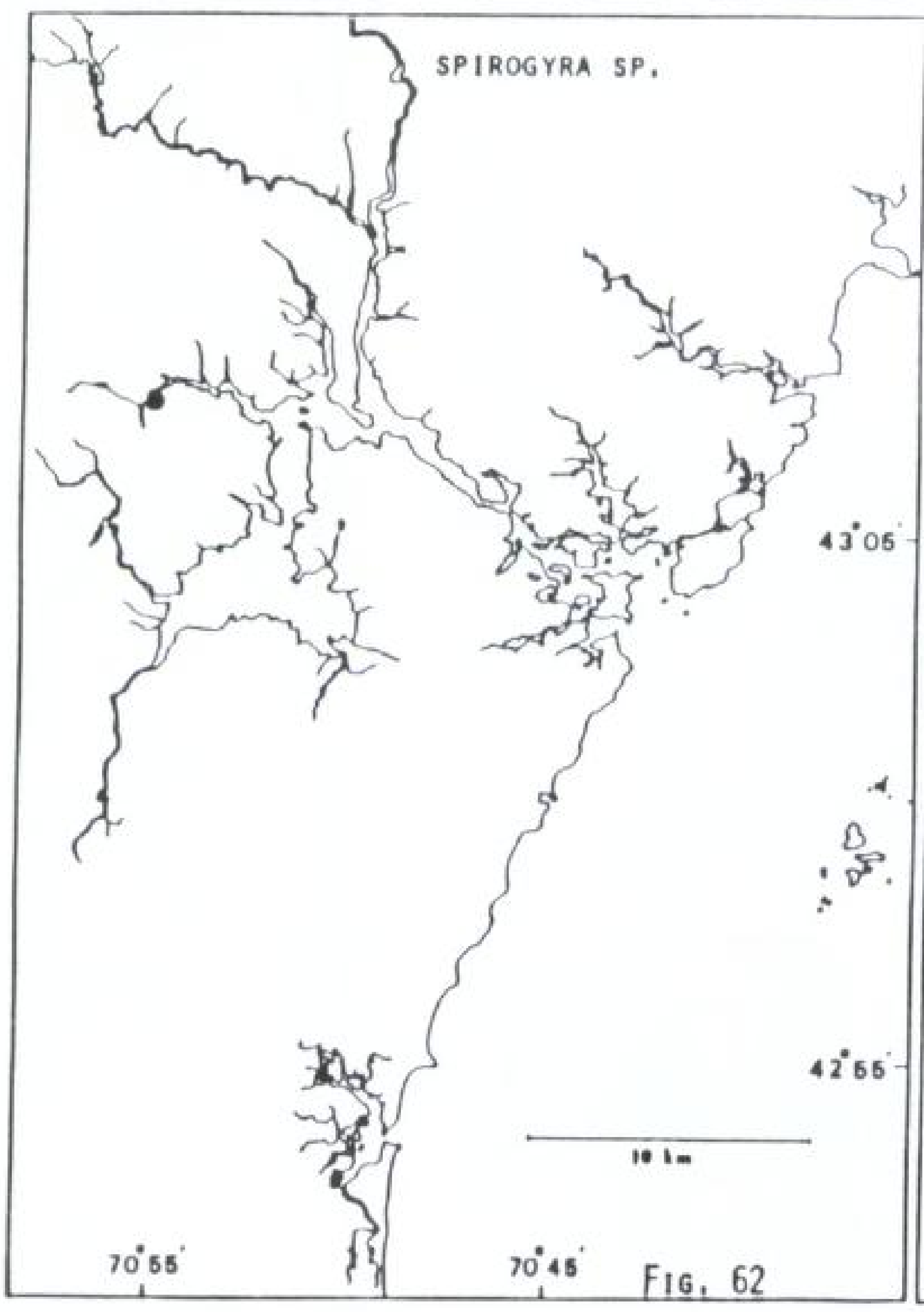


Fig. 62

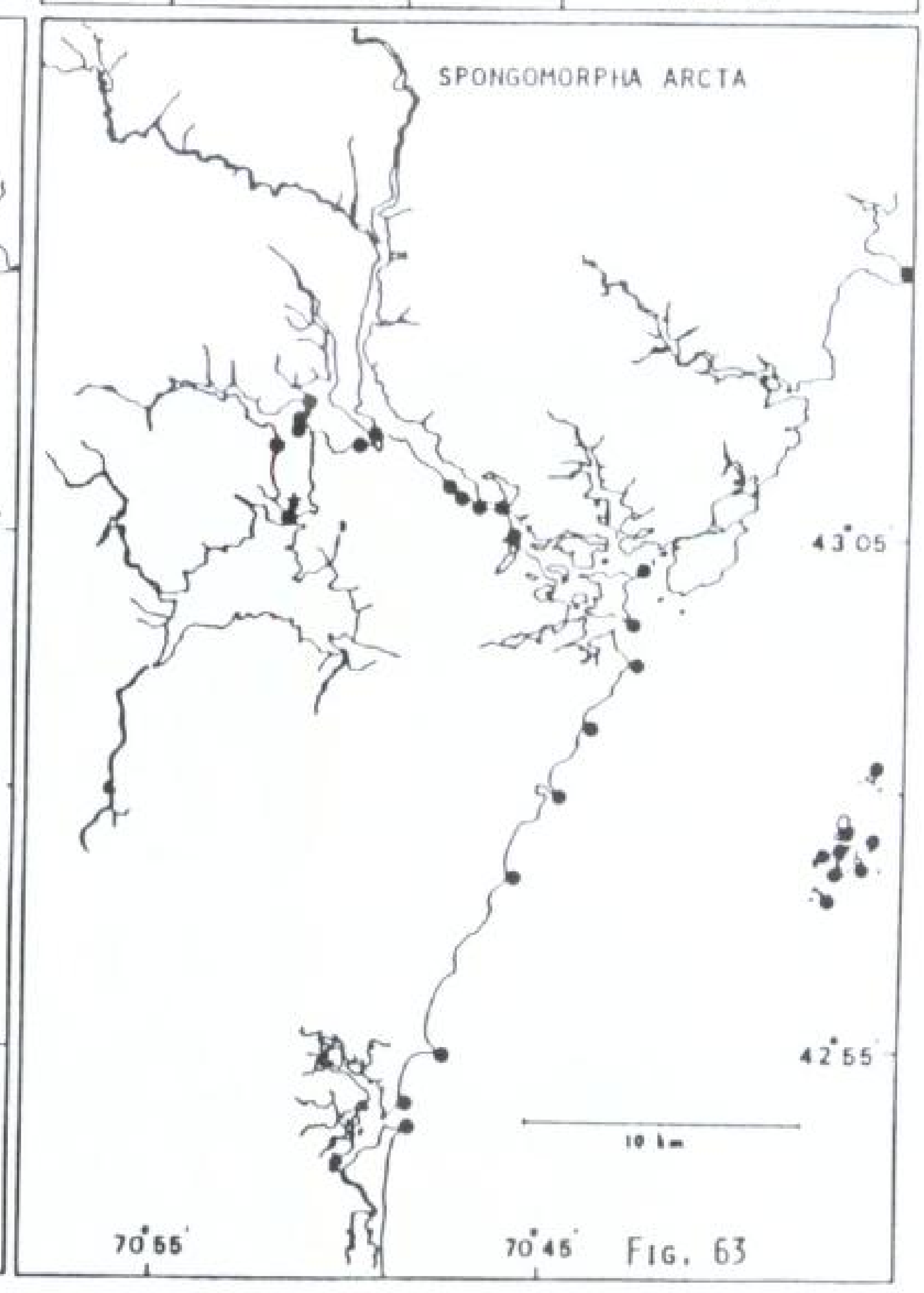


Fig. 63

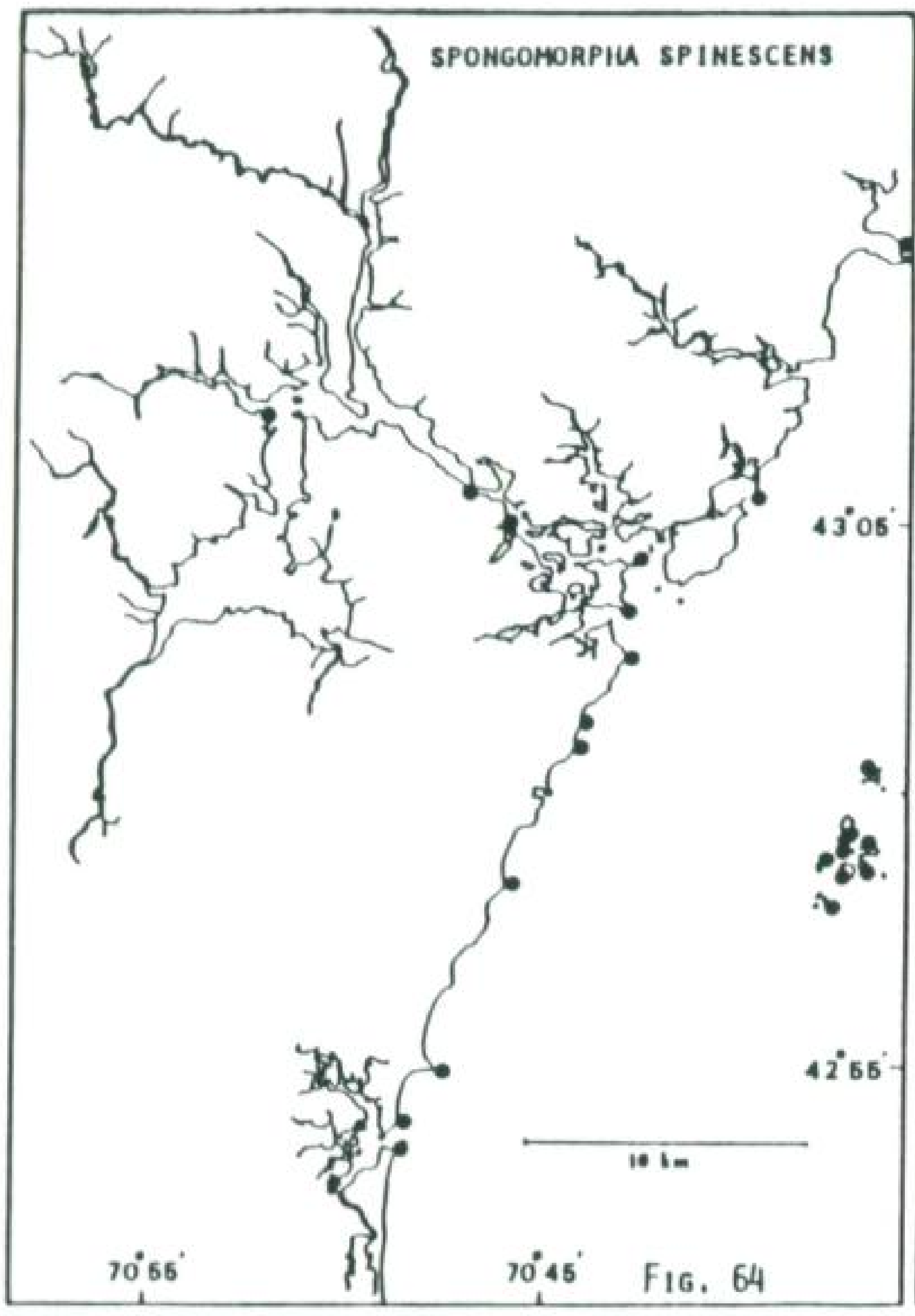


FIG. 64

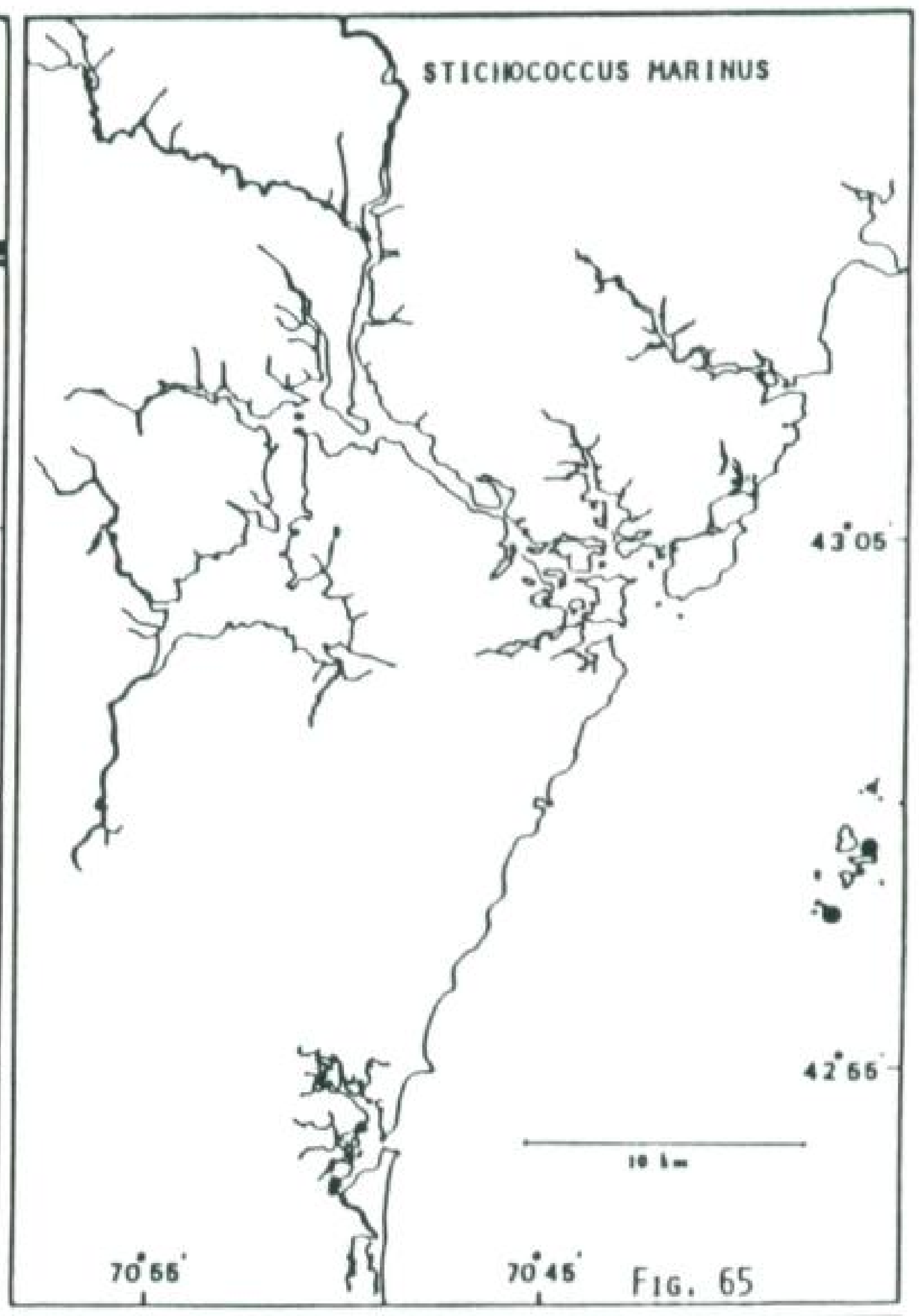


FIG. 65

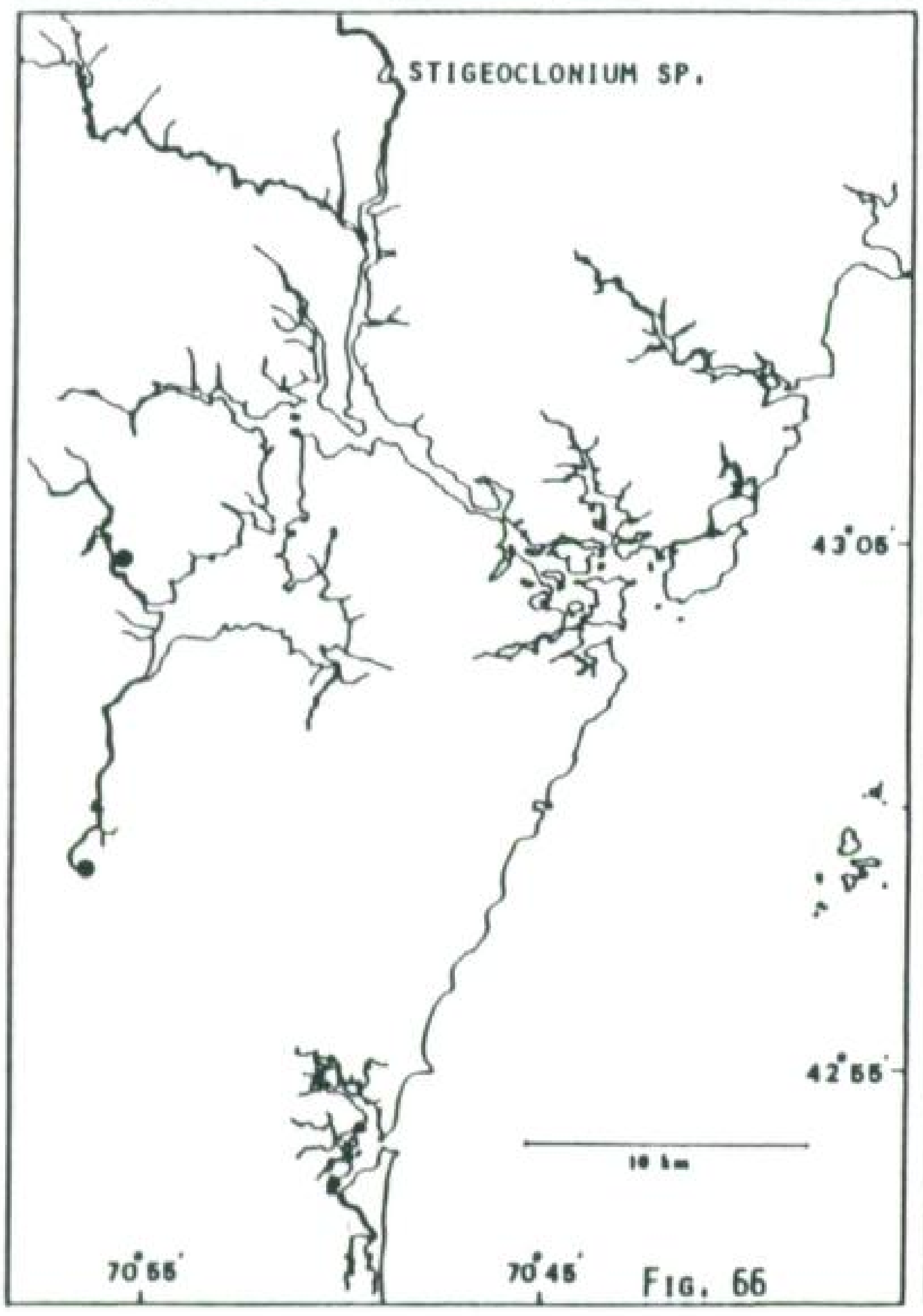


FIG. 66

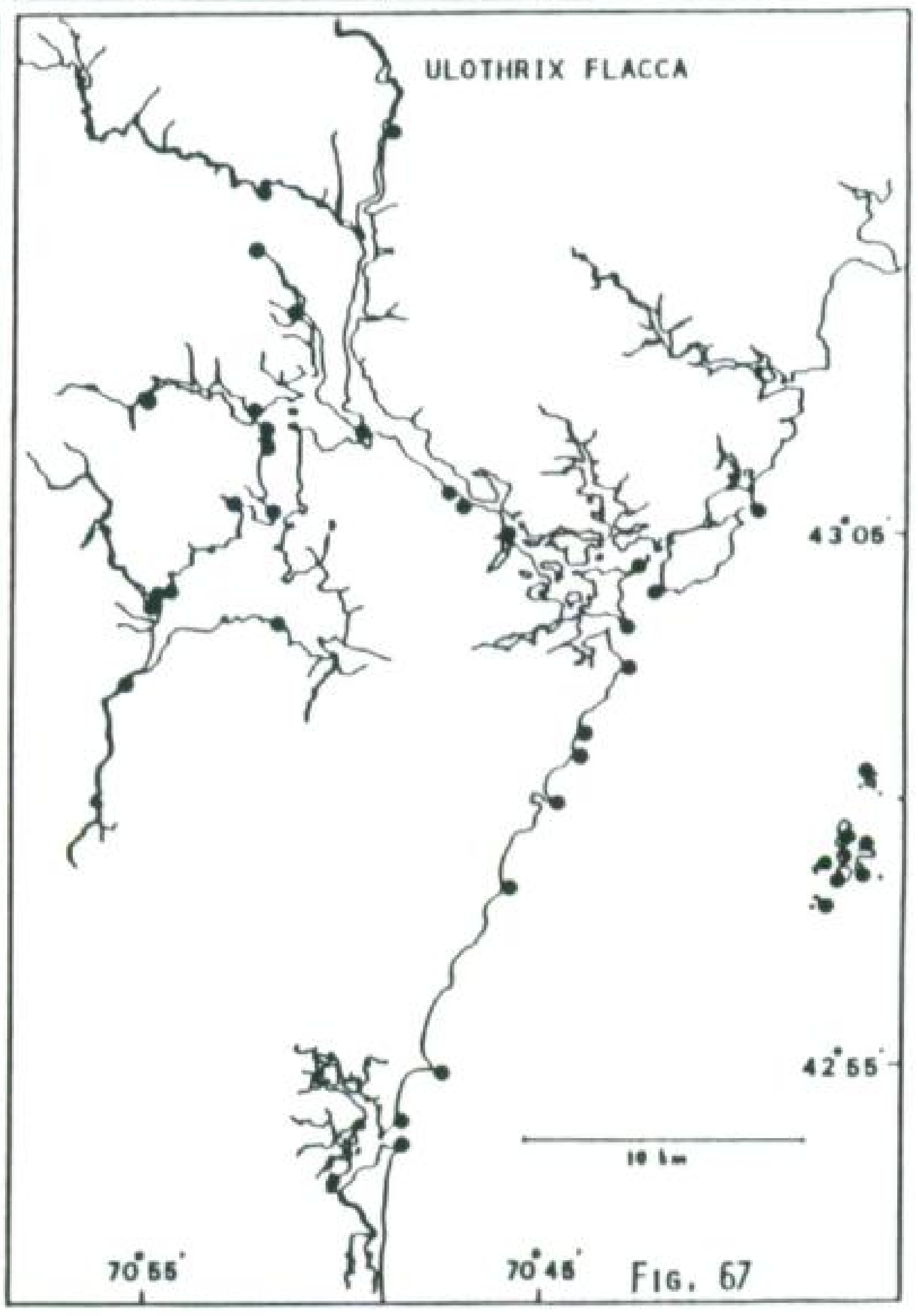
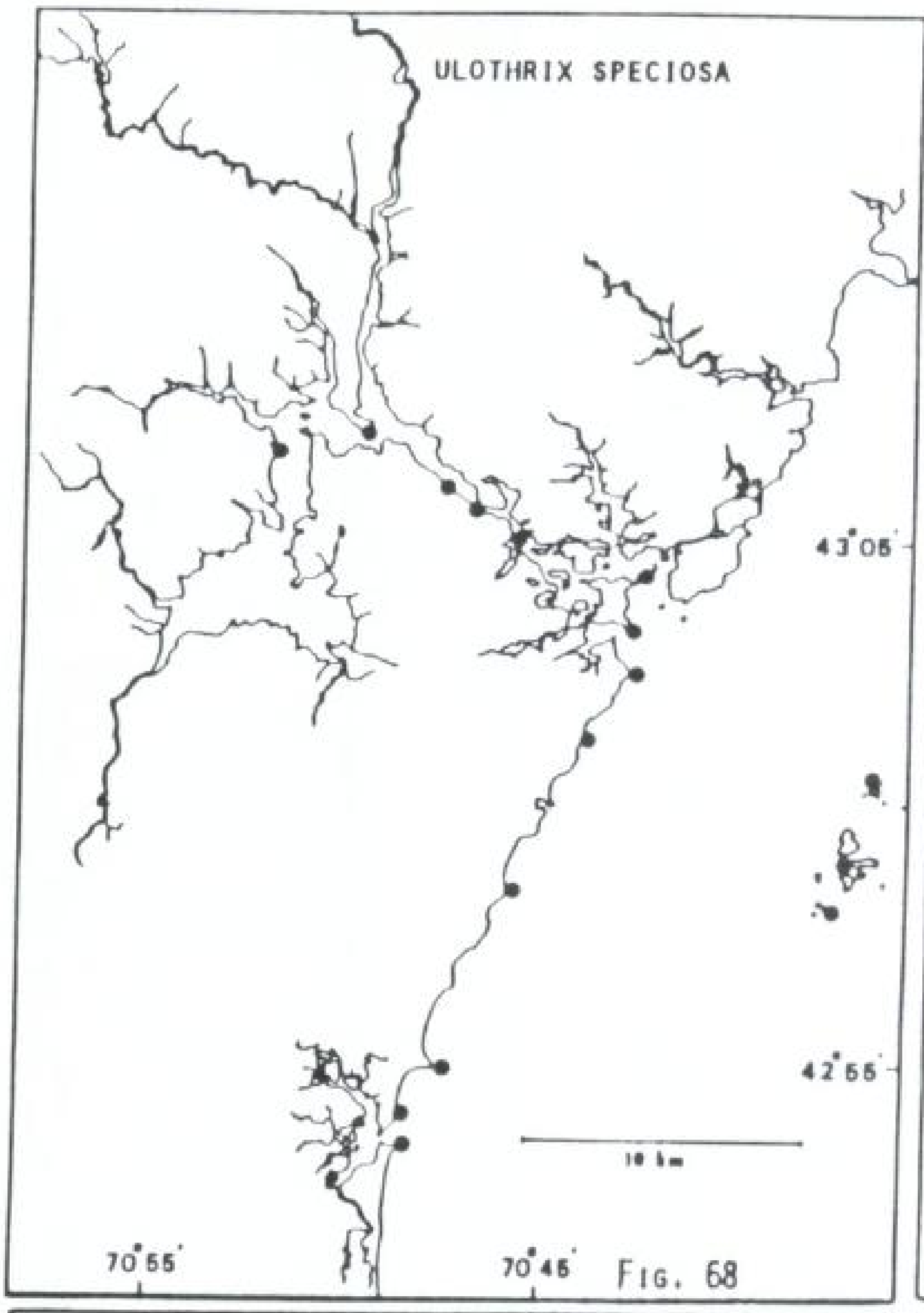
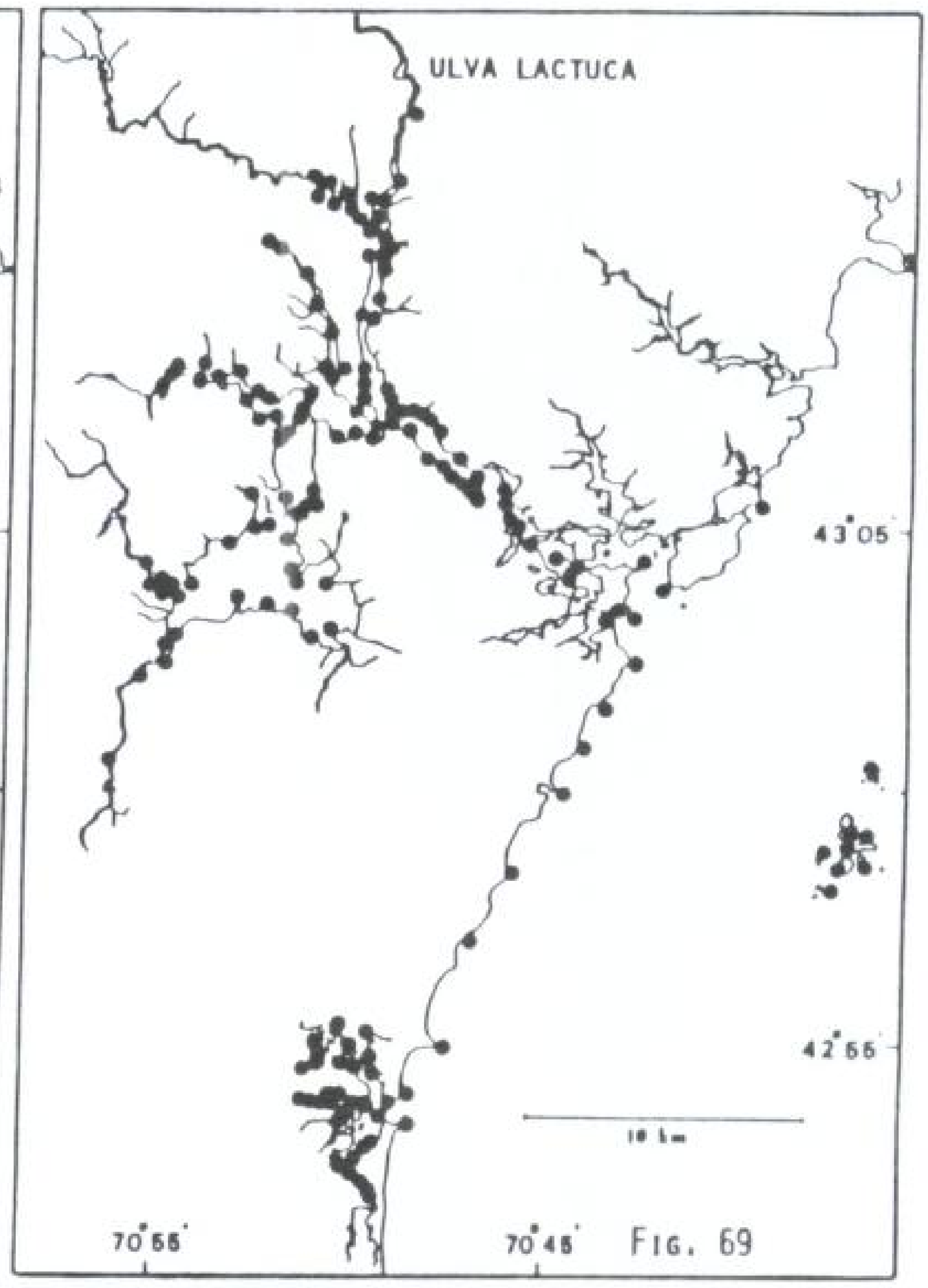
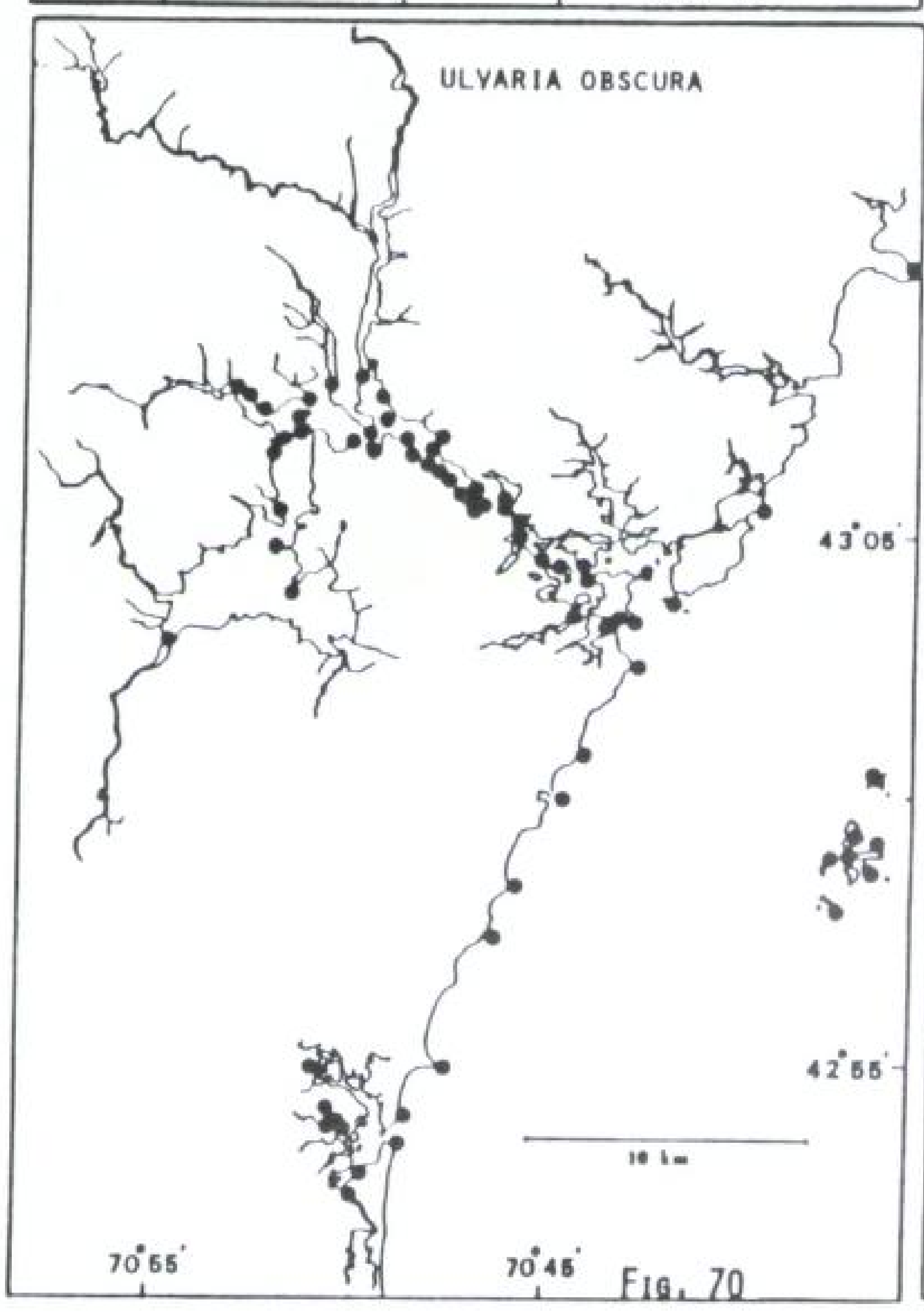
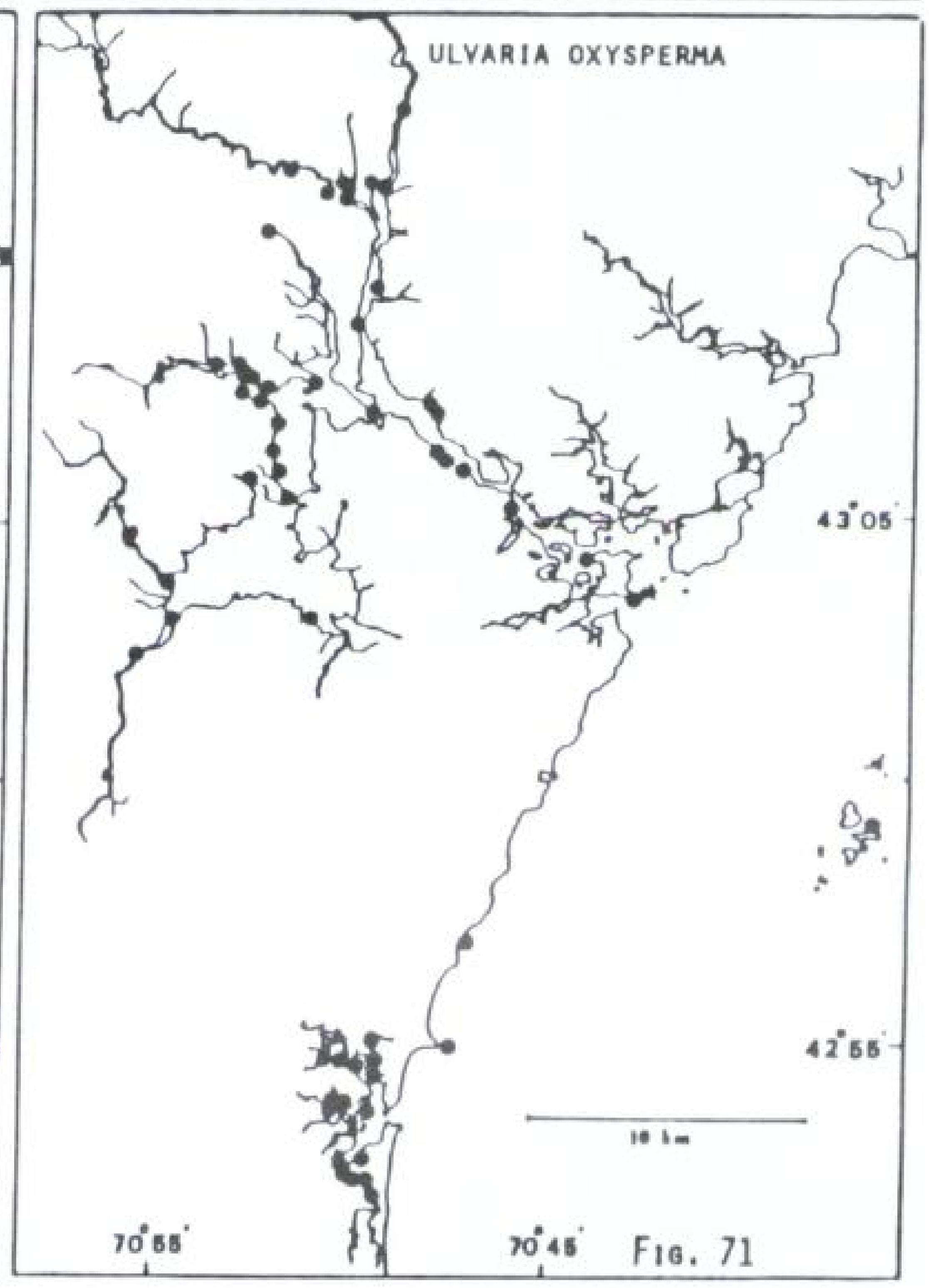


FIG. 67


ULOTHRIX SPECIOSA
43°05'
42°55'
10 km
70°55'
70°45'
FIG. 68


ULVA LACTUCA
43°05'
42°55'
10 km
70°55'
70°45'
FIG. 69


ULVARIA OBSCURA
43°05'
42°55'
10 km
70°55'
70°45'
FIG. 70


ULVARIA OXYSPERMA
43°05'
42°55'
10 km
70°55'
70°45'
FIG. 71

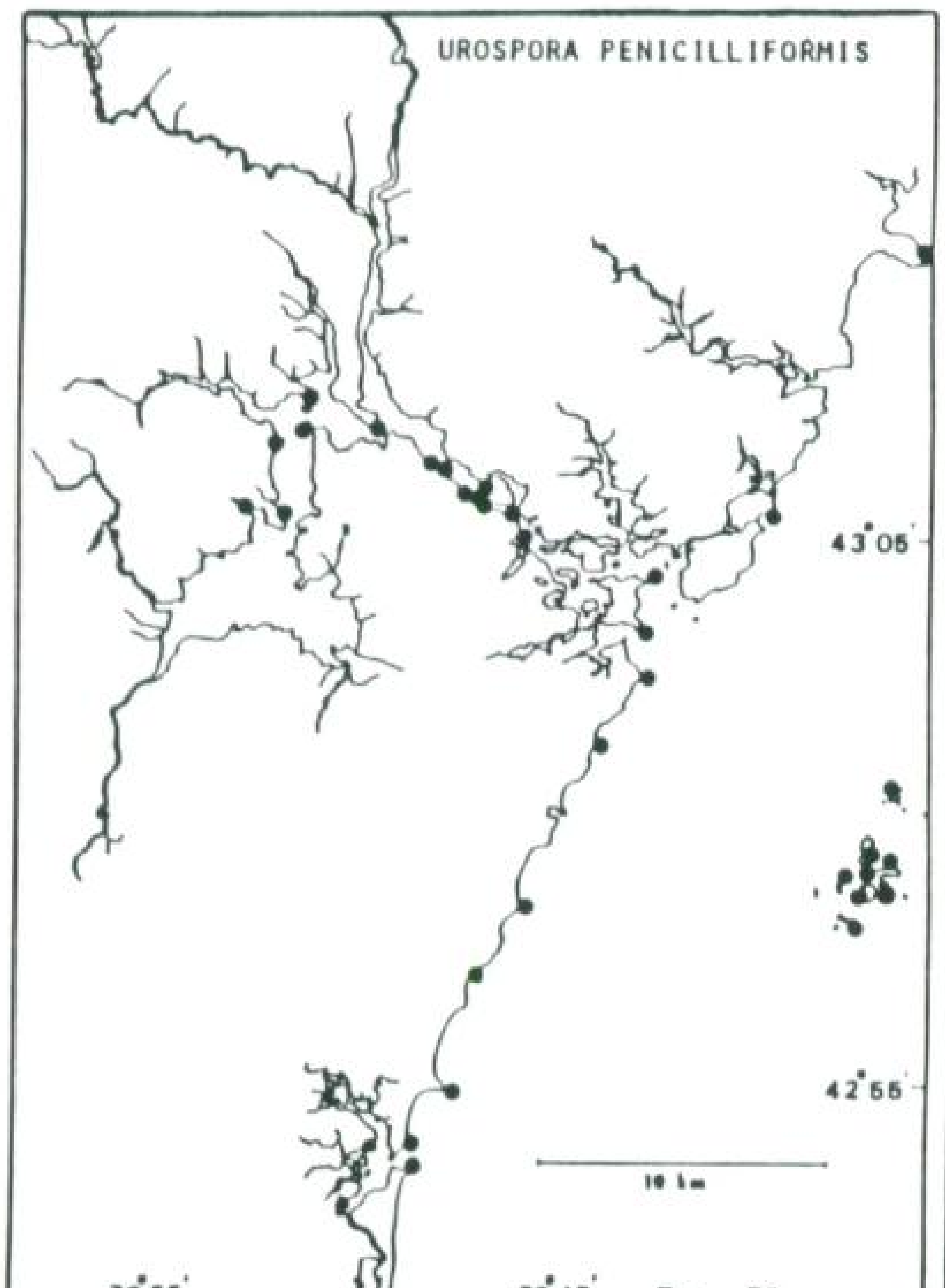


FIG. 72

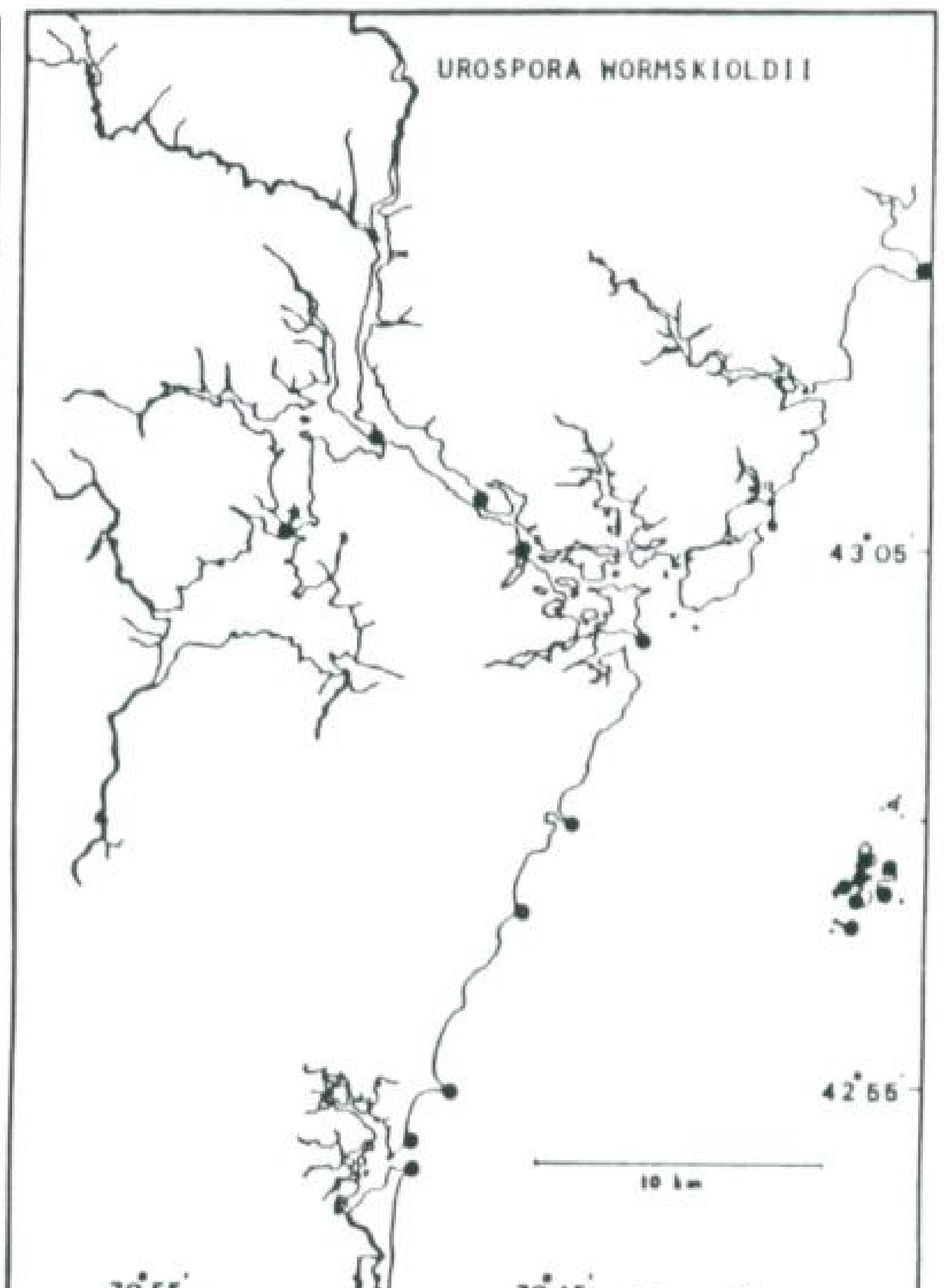


FIG. 73

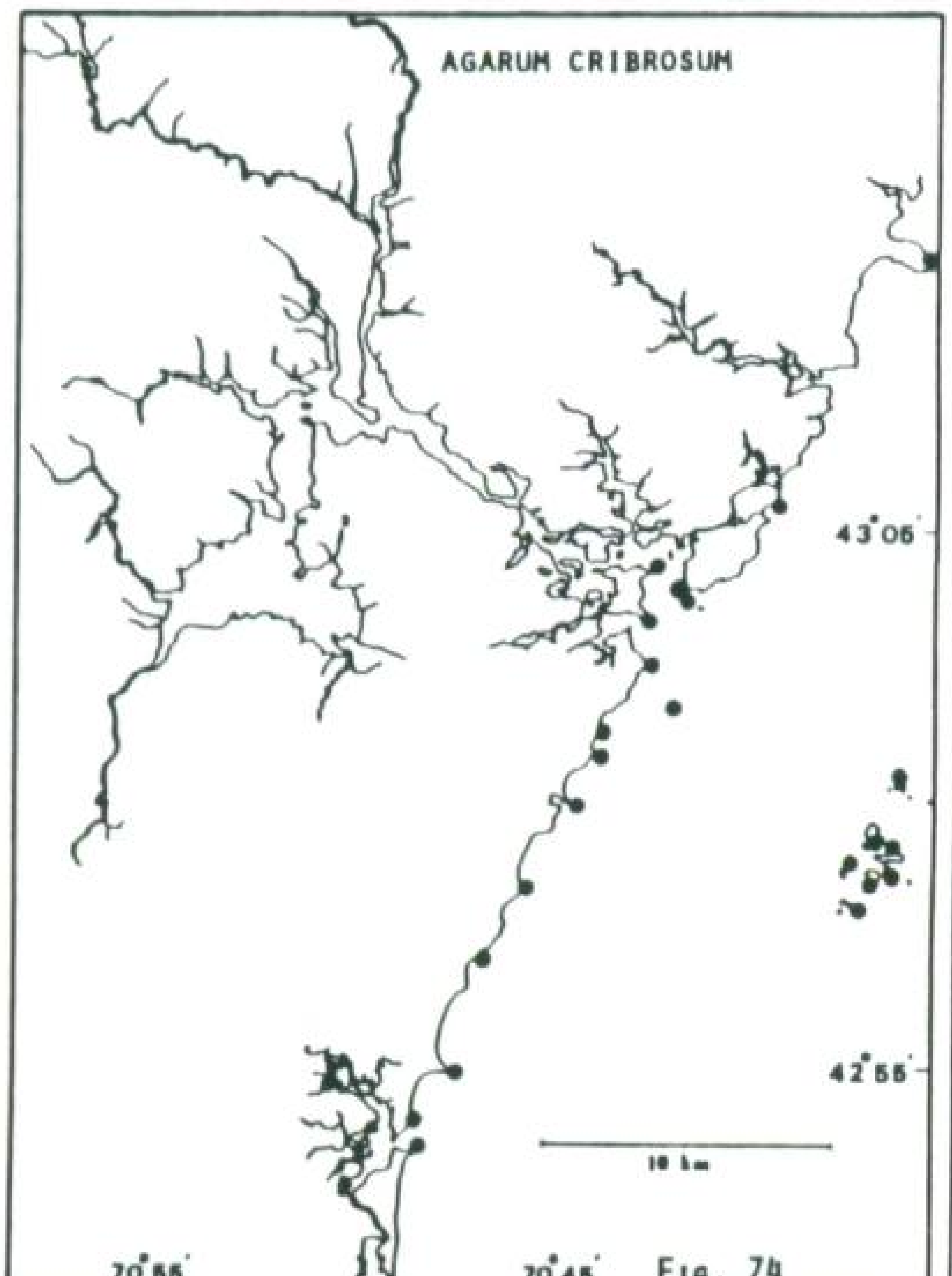


FIG. 74

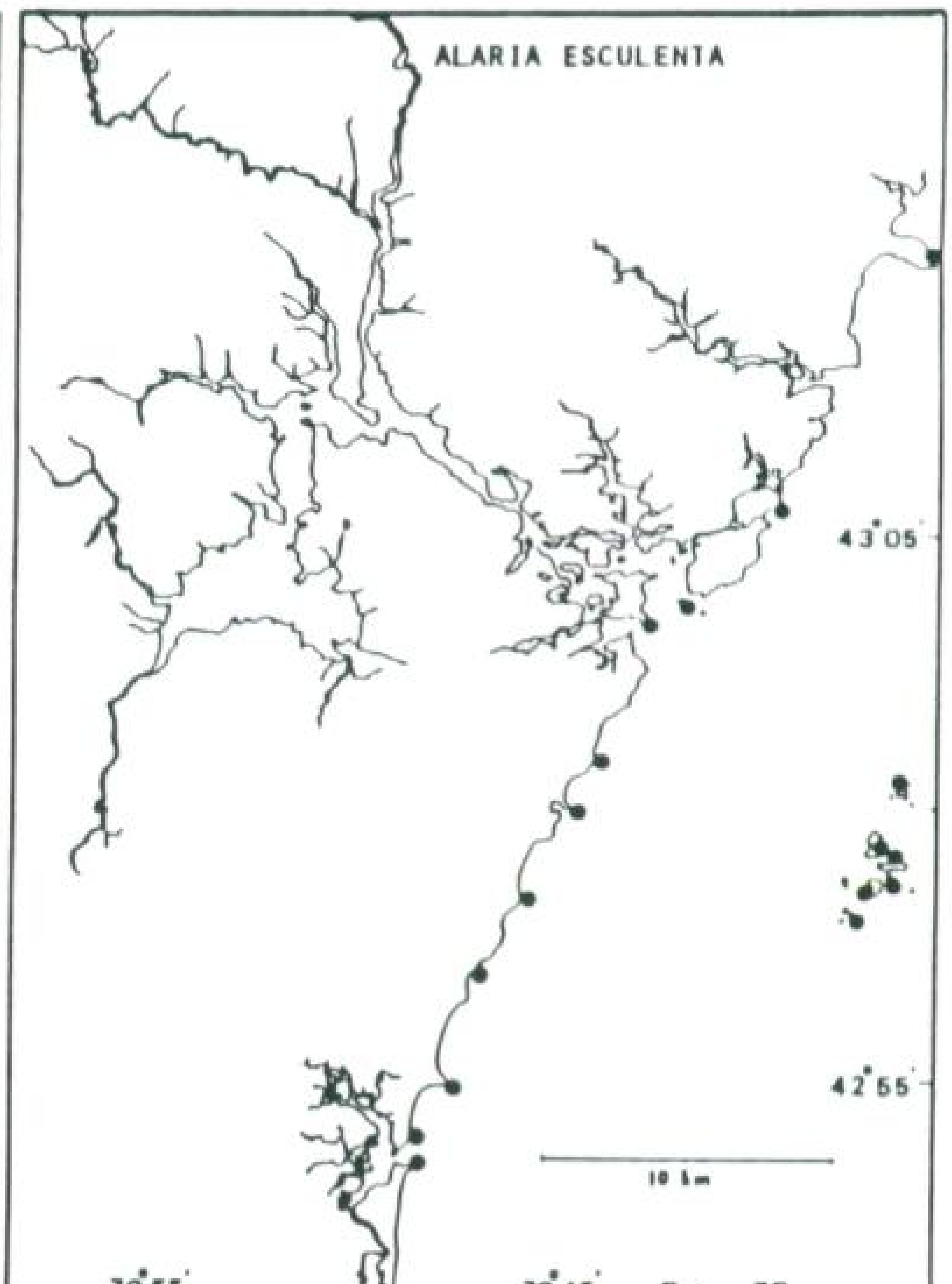


FIG. 75

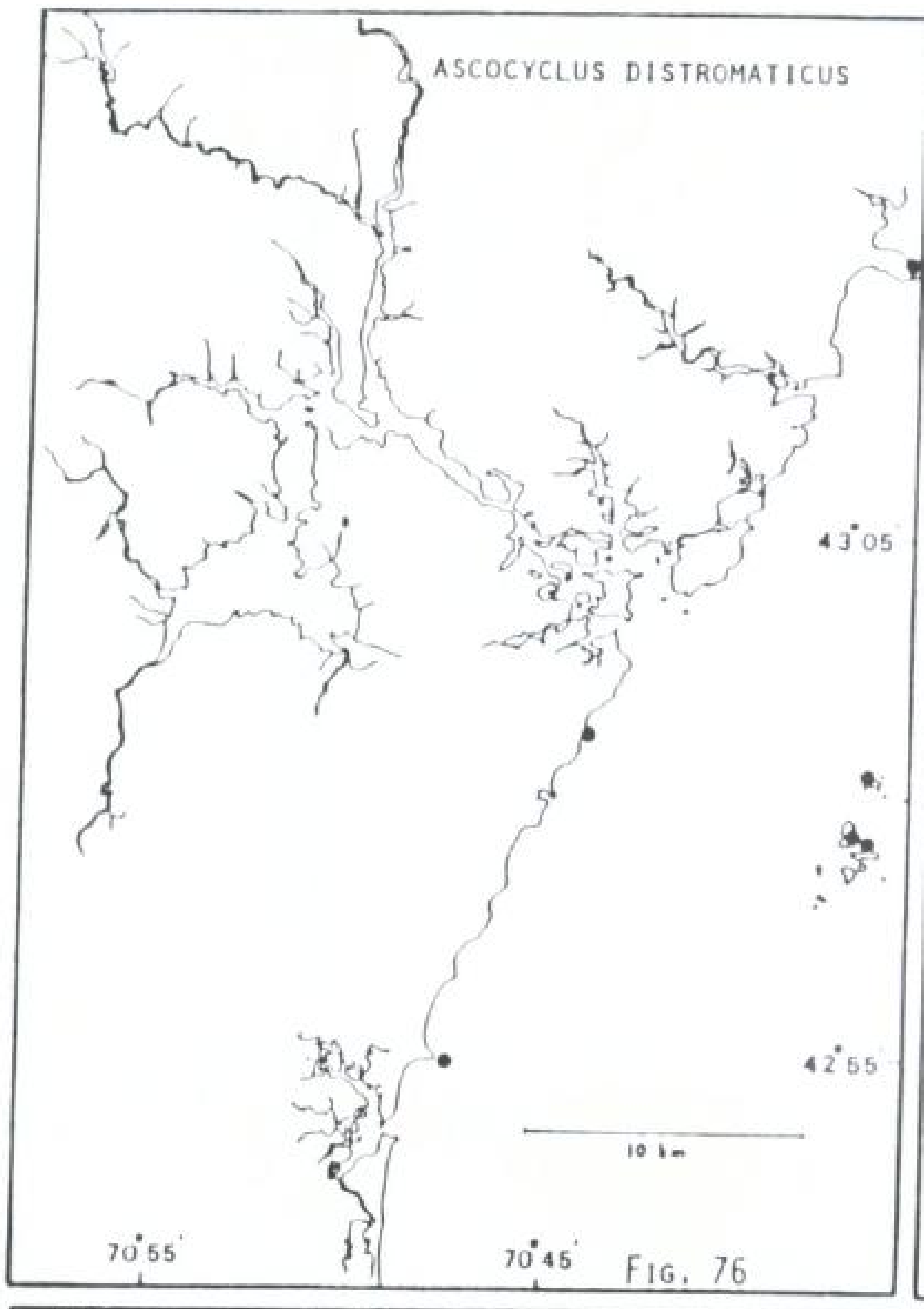


Fig. 76

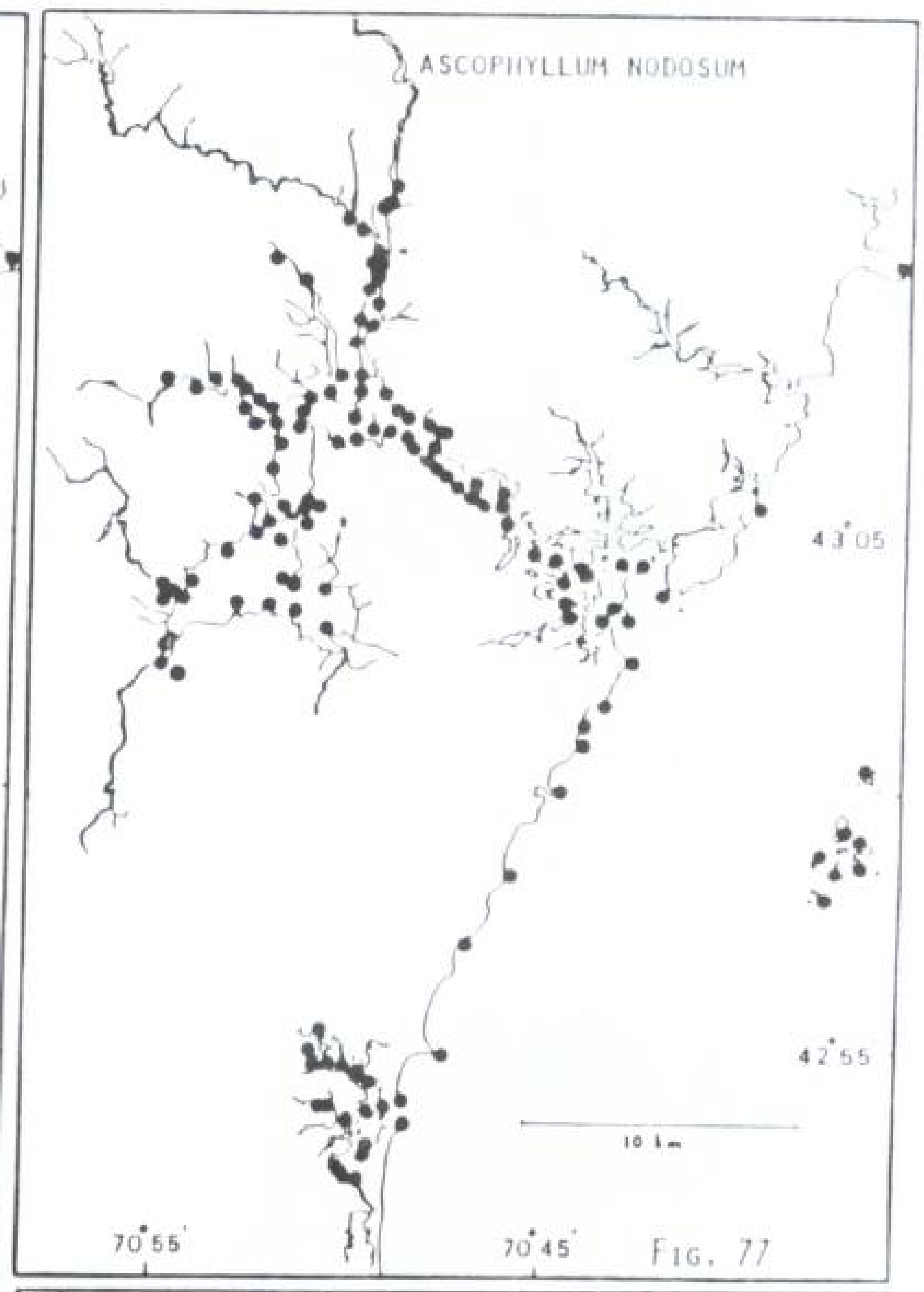


Fig. 77

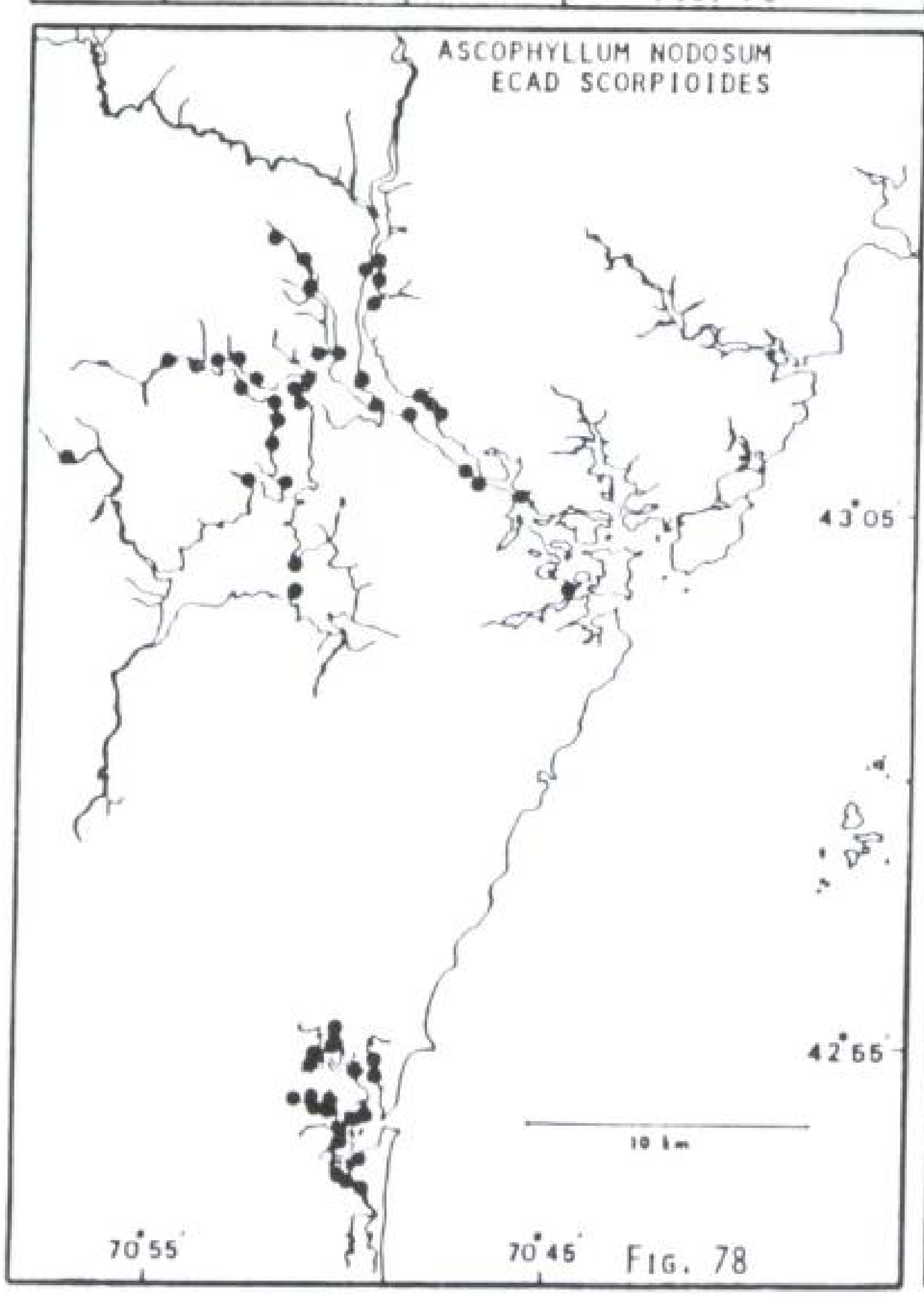


Fig. 78

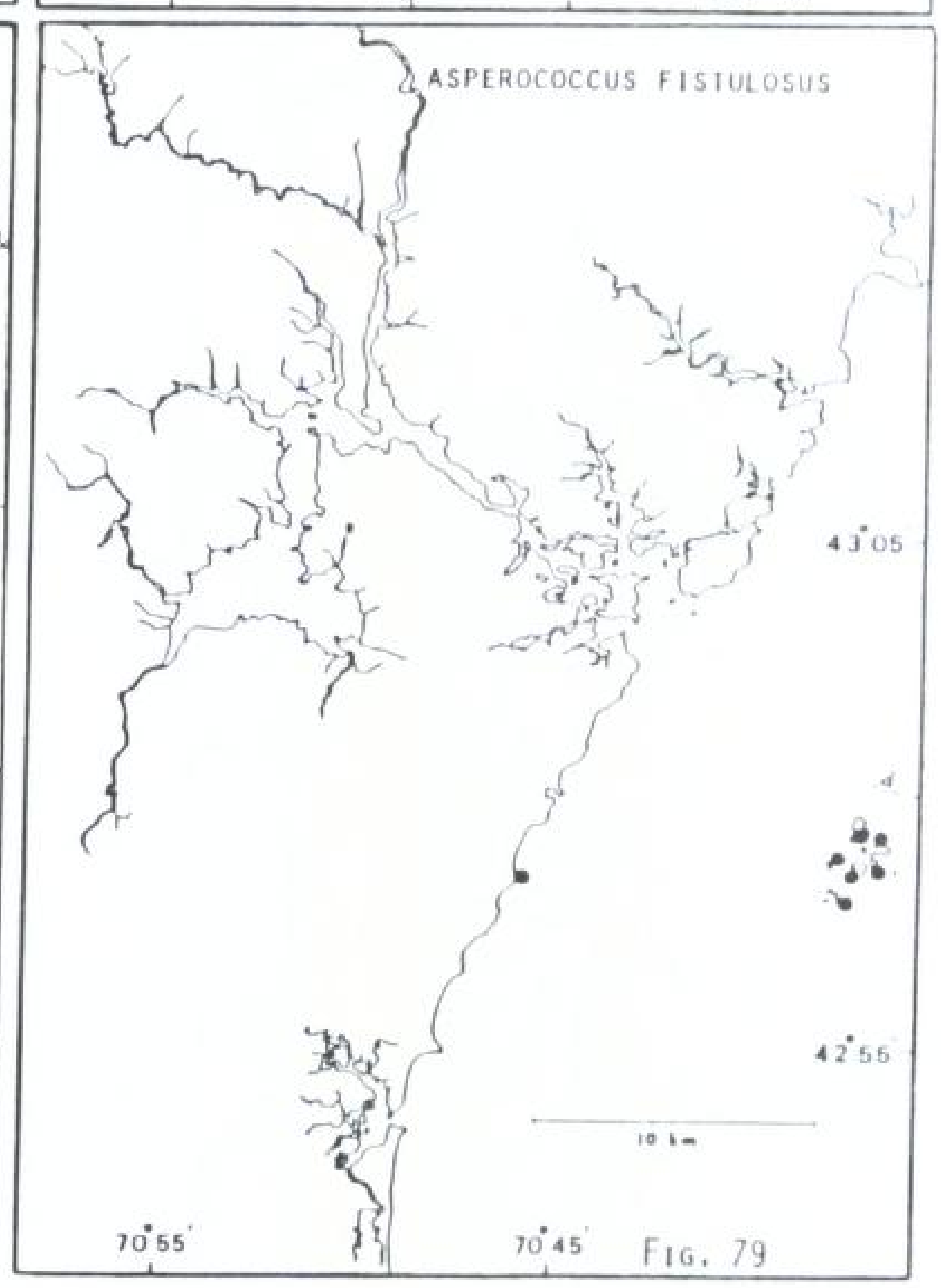


Fig. 79

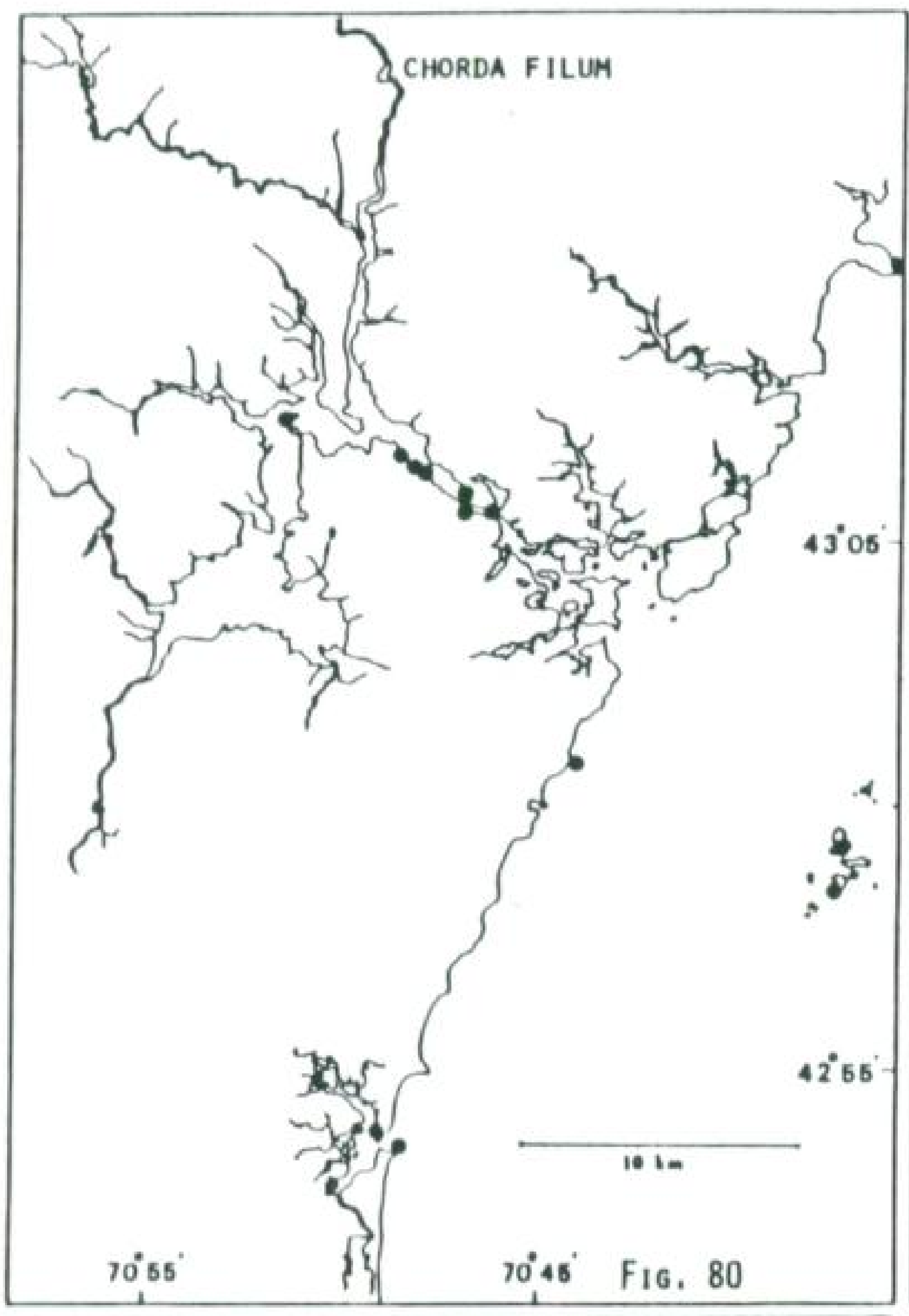


Fig. 80

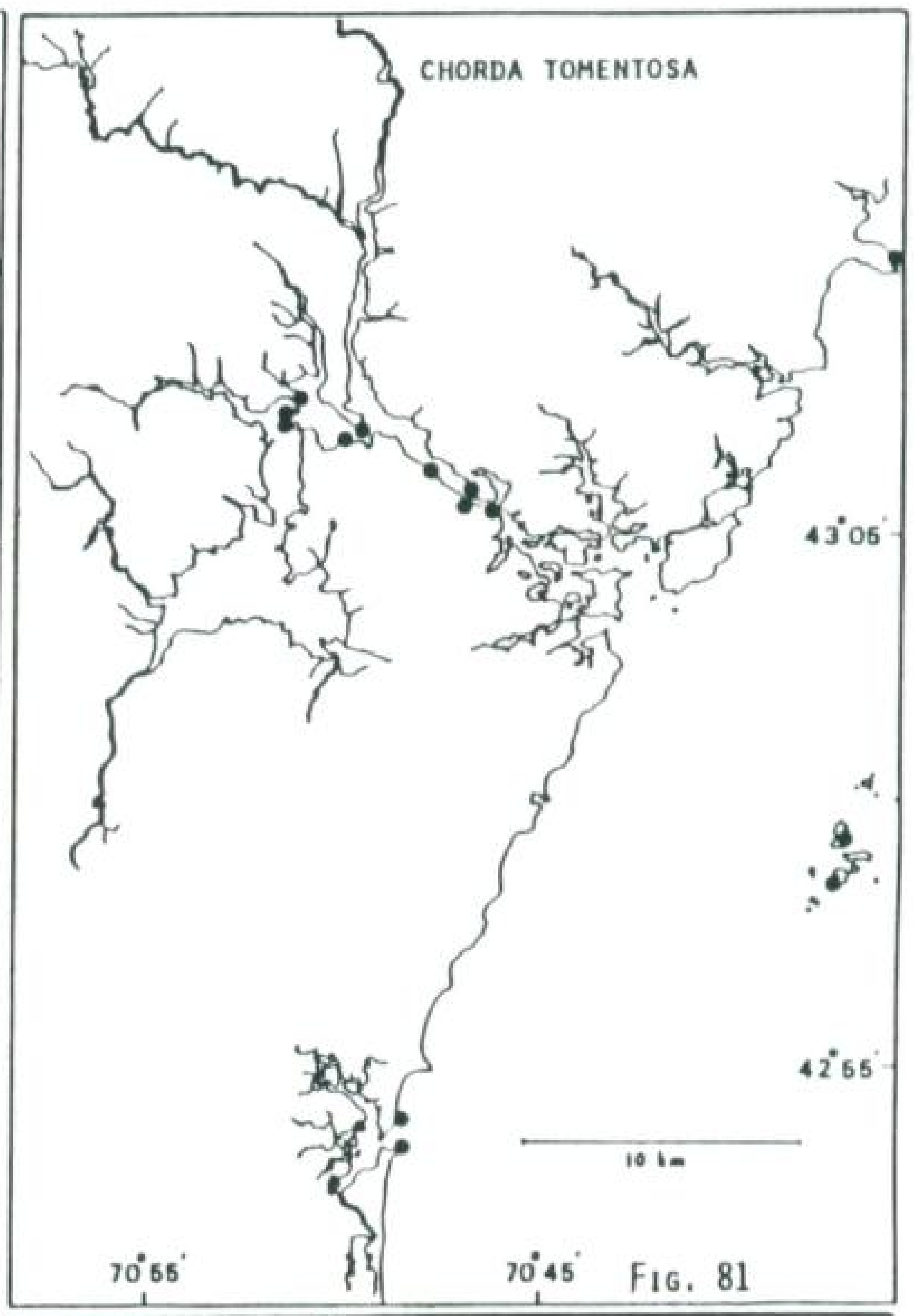


Fig. 81

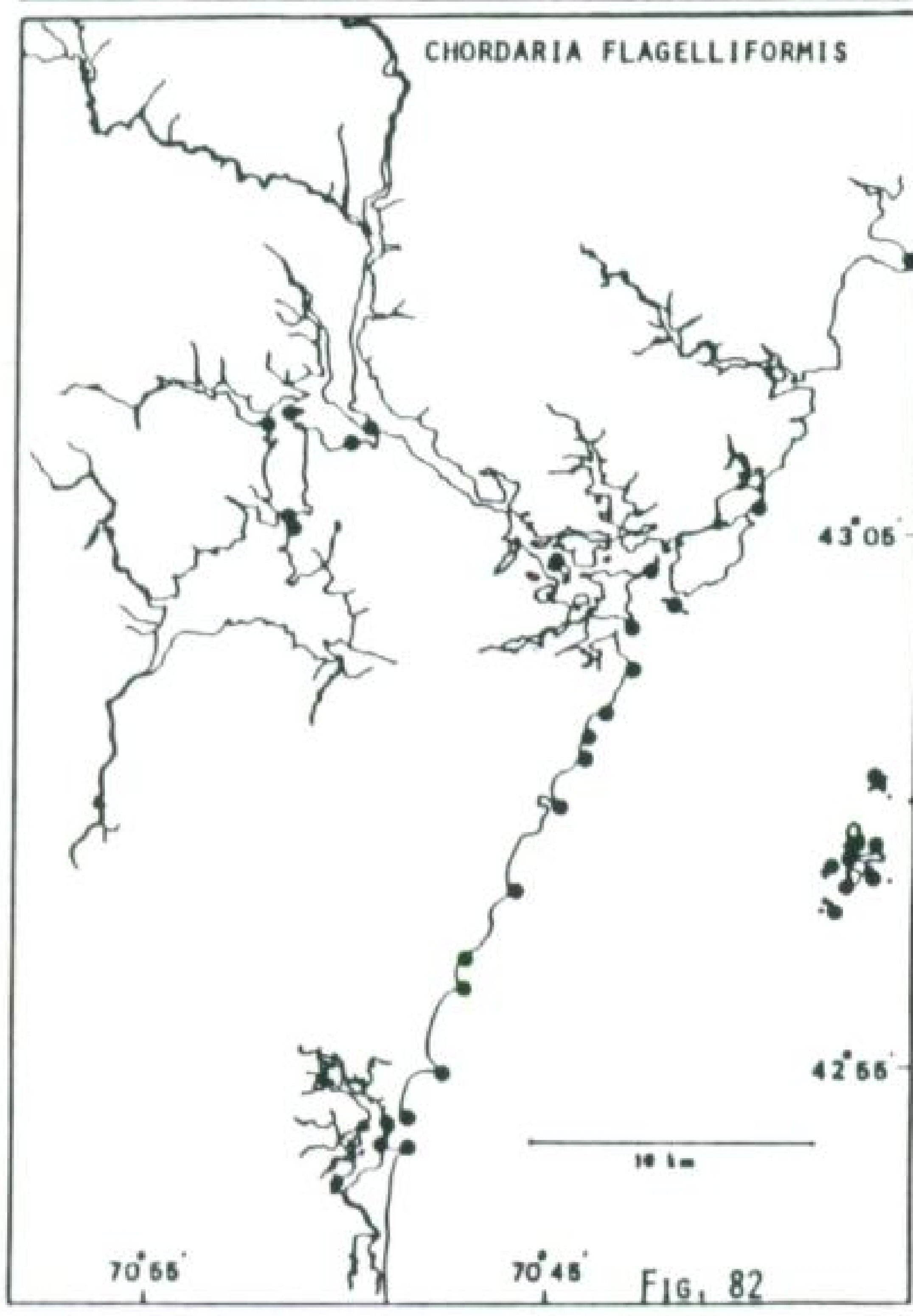


Fig. 82

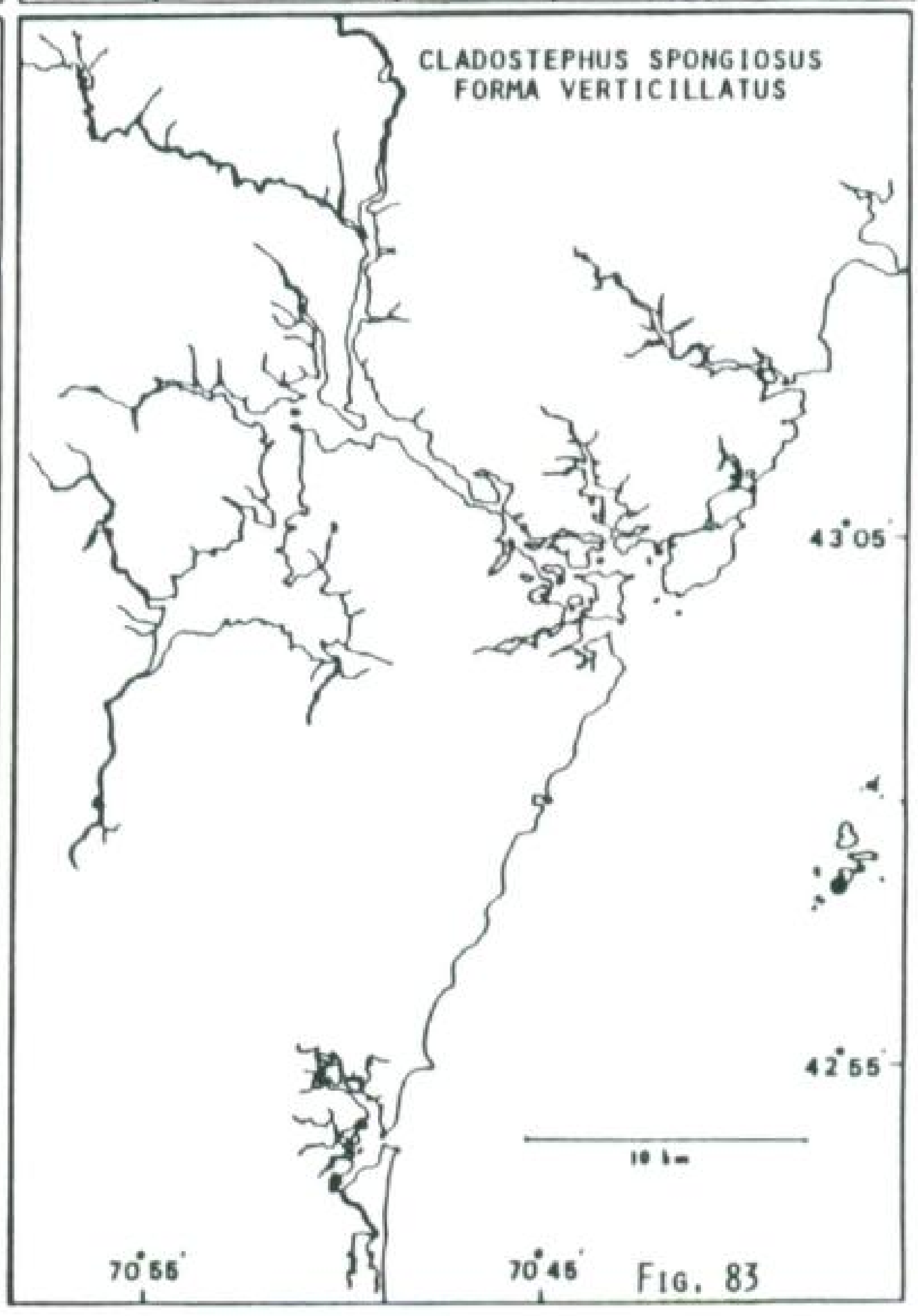


Fig. 83

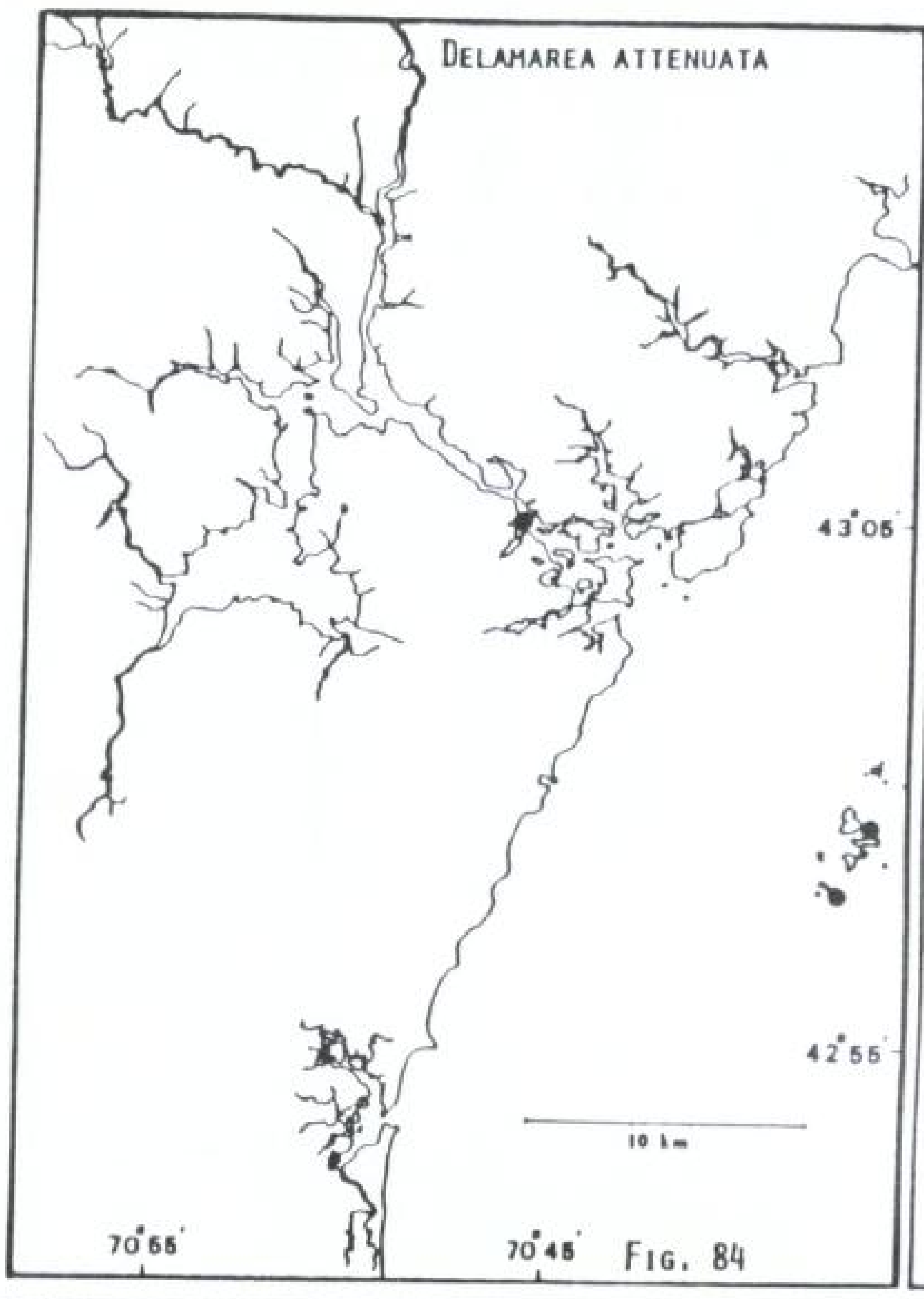


Fig. 84

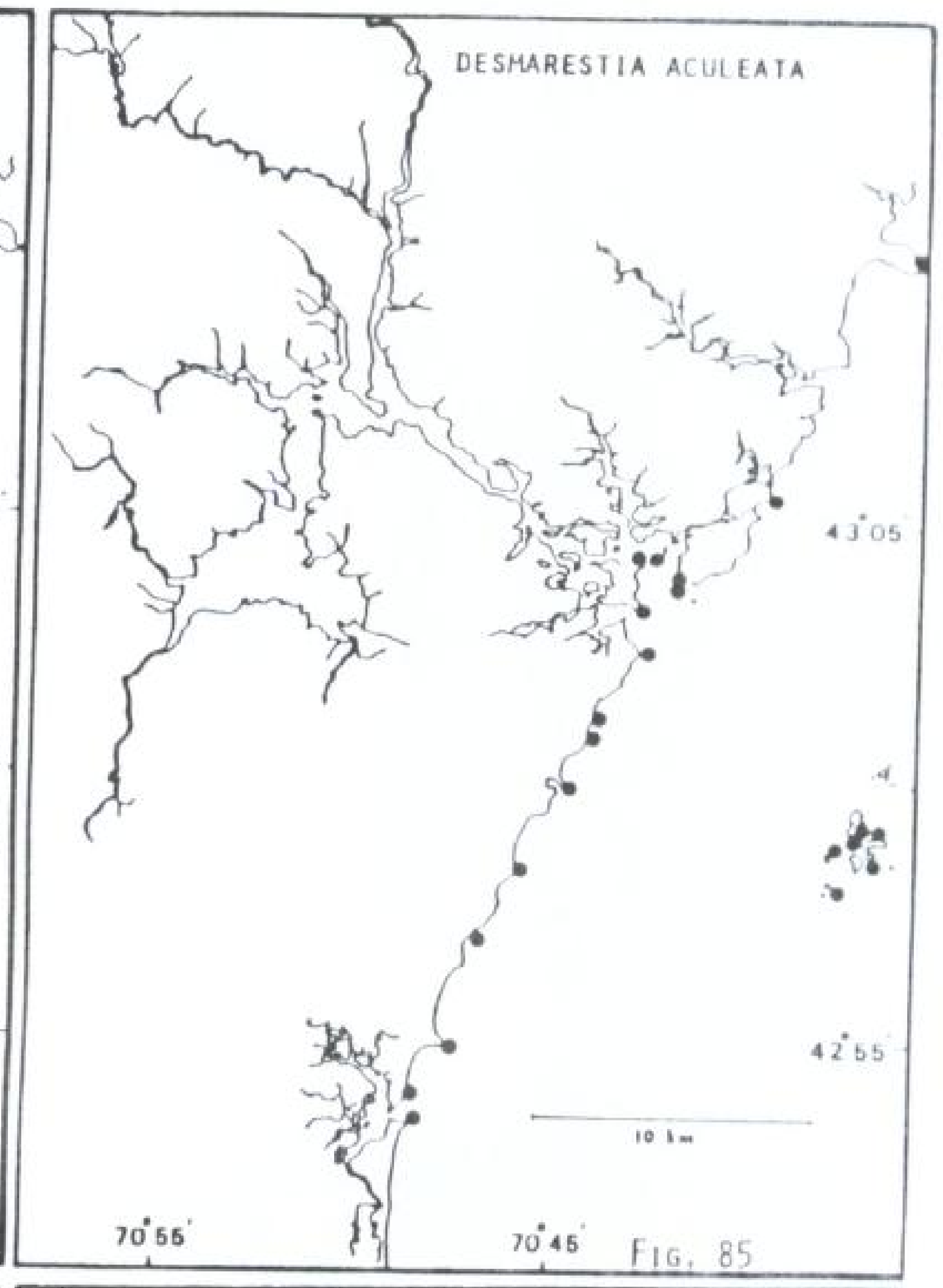


Fig. 85

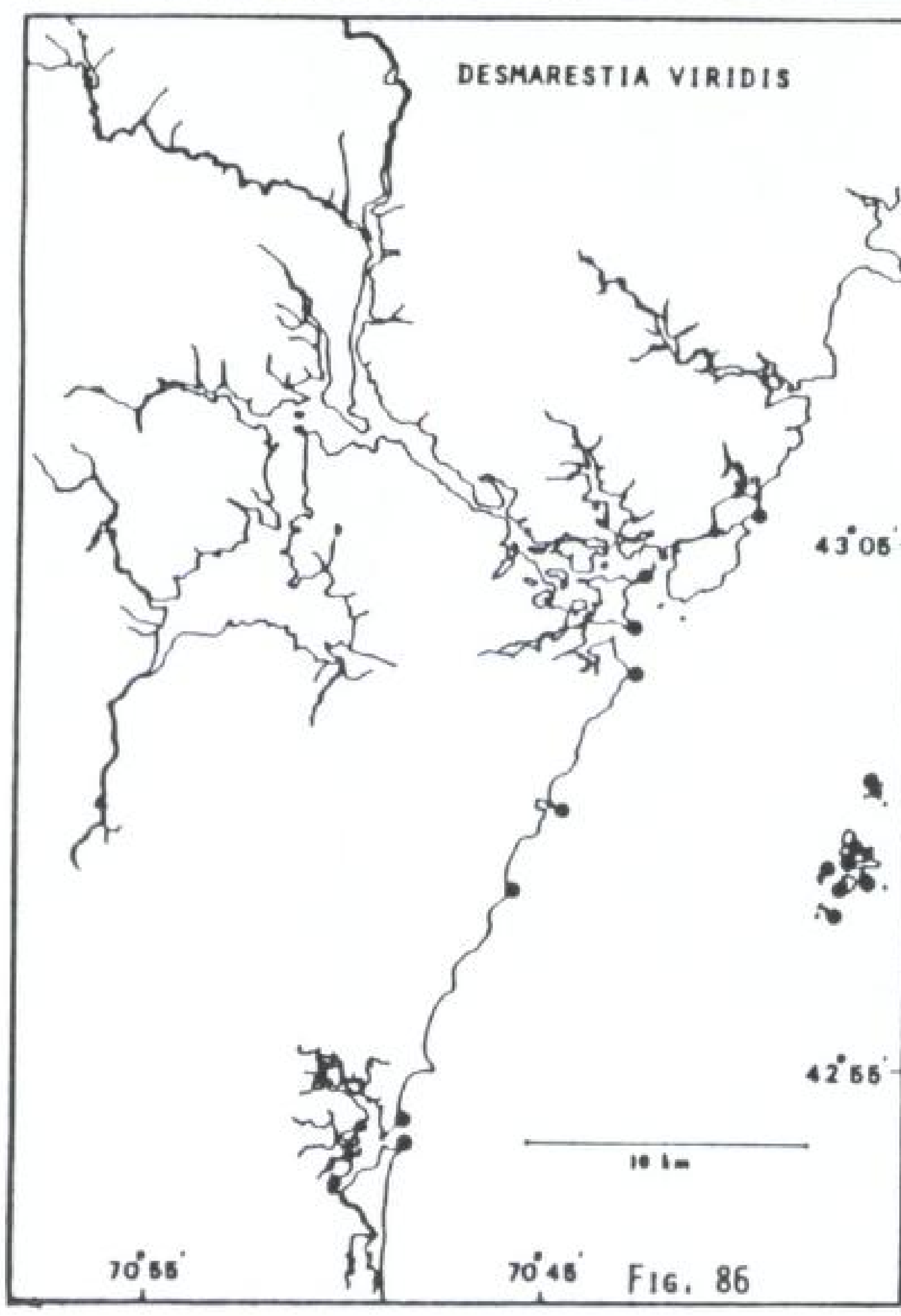


Fig. 86

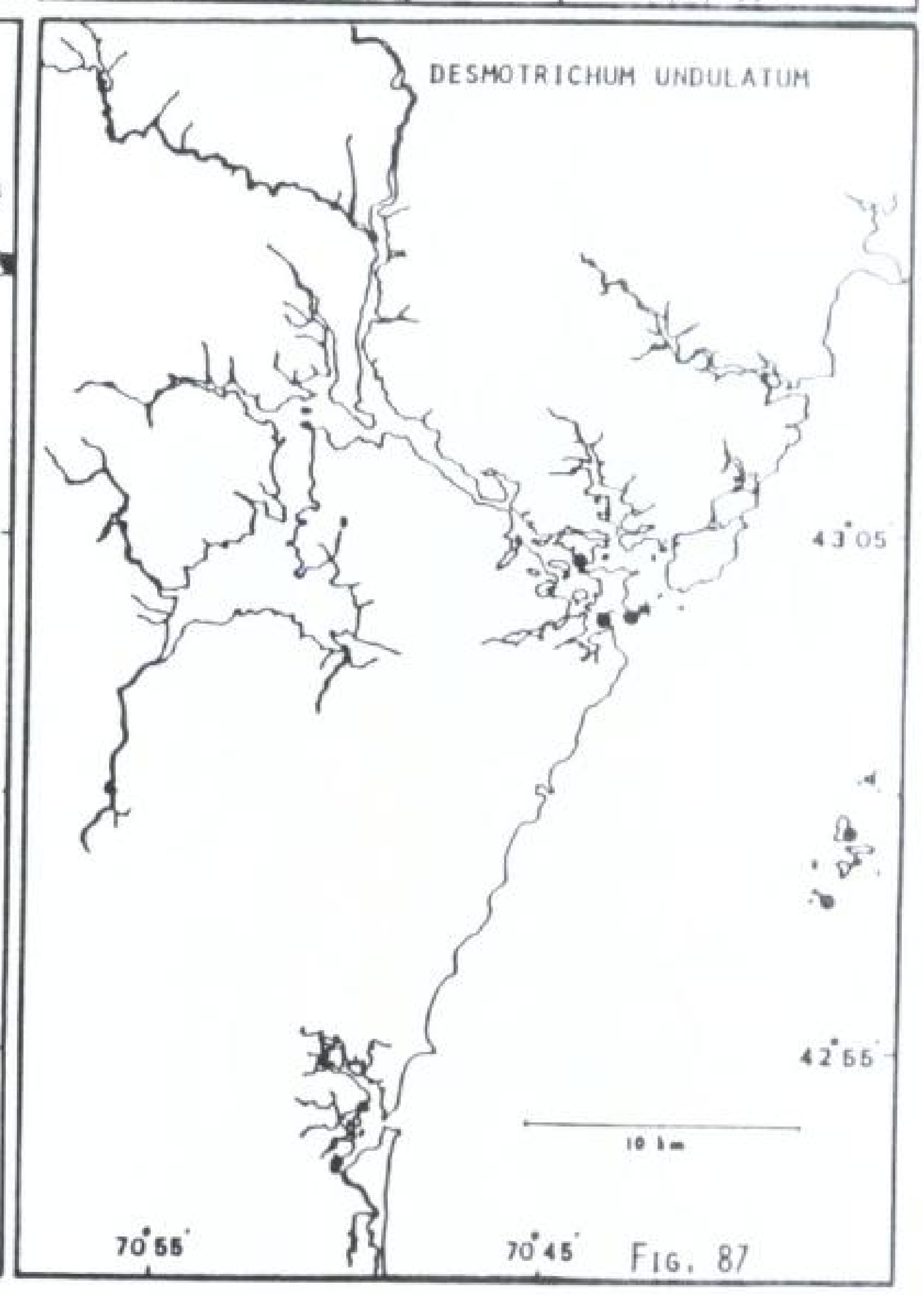


Fig. 87

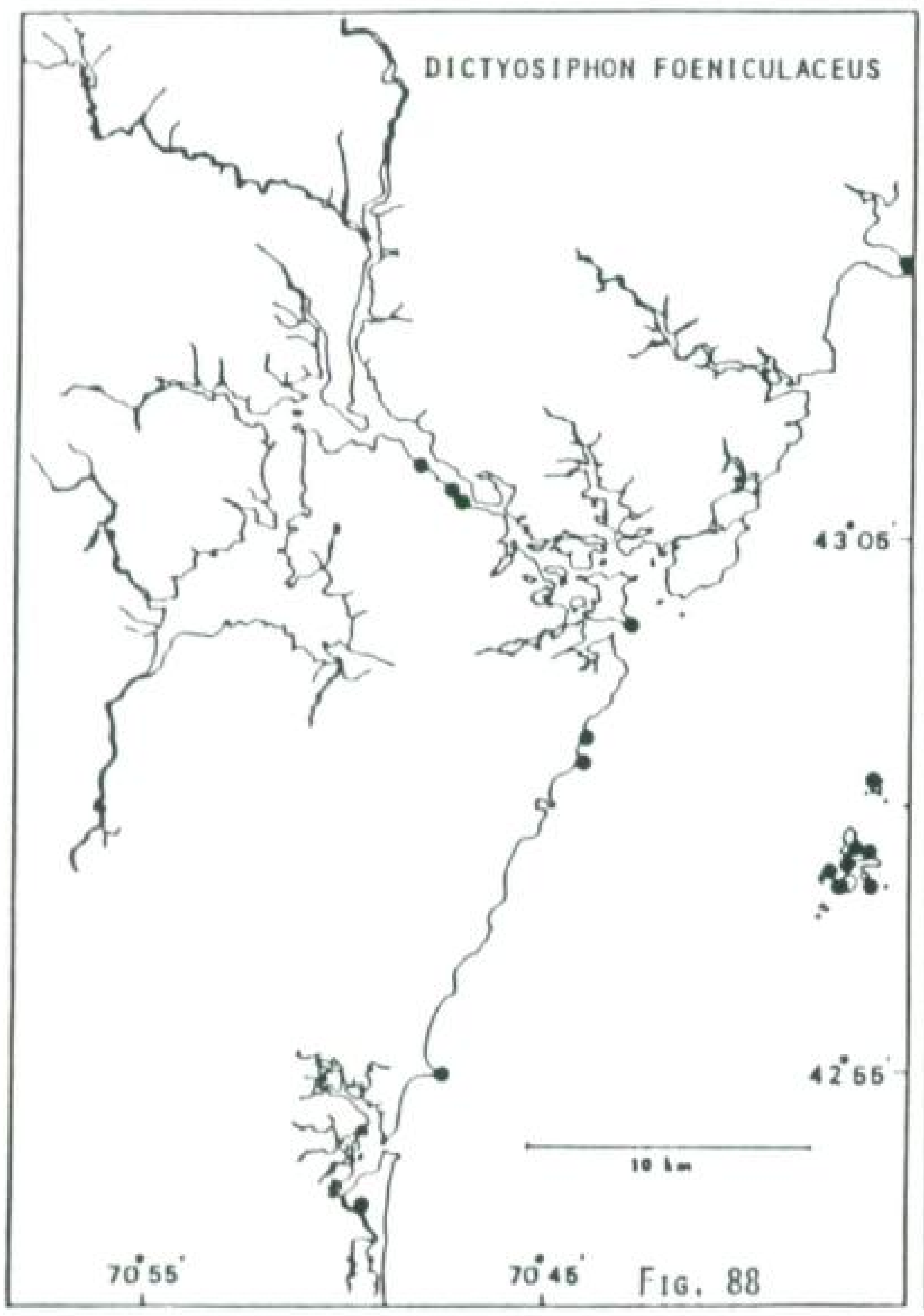


FIG. 88

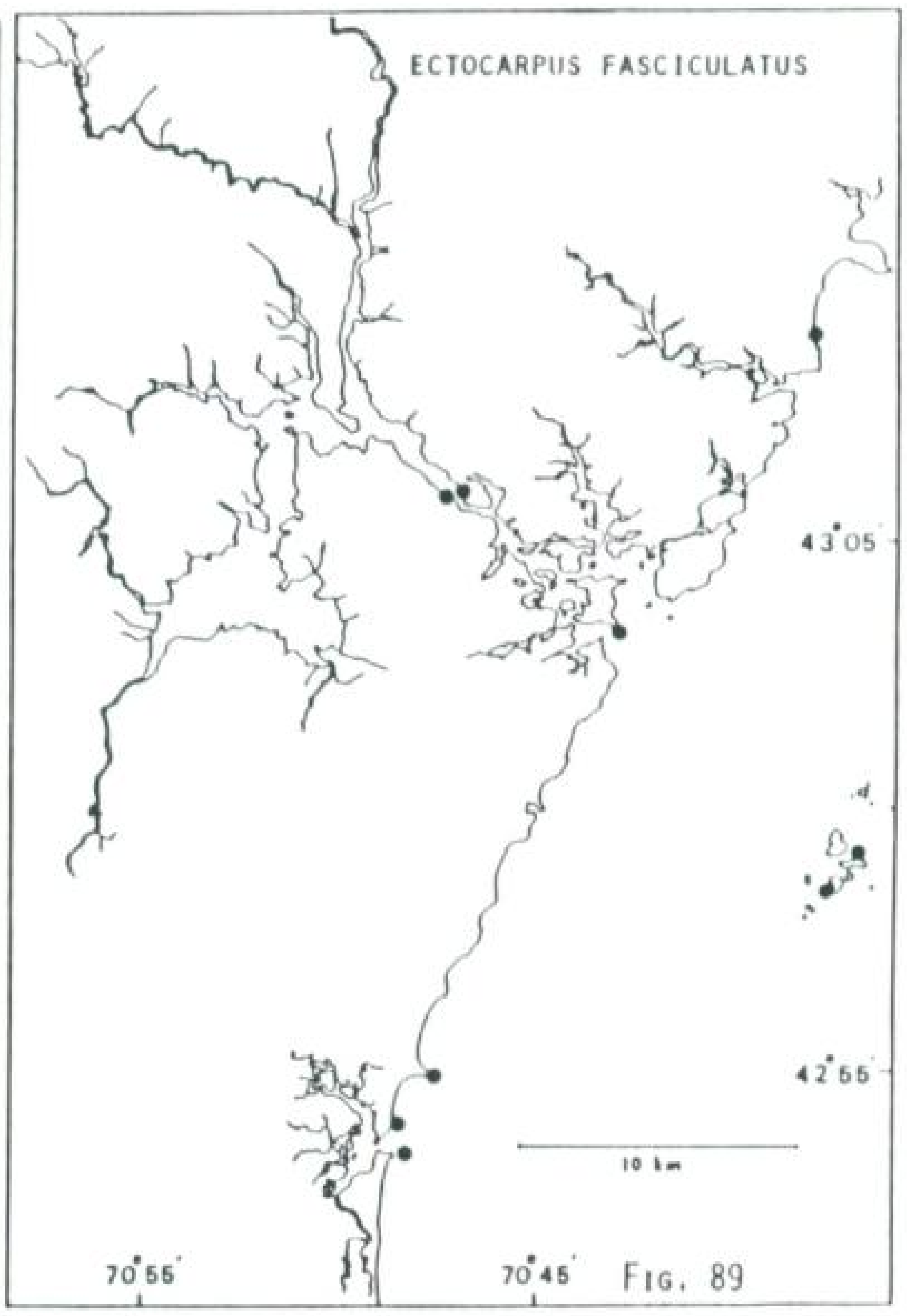


FIG. 89

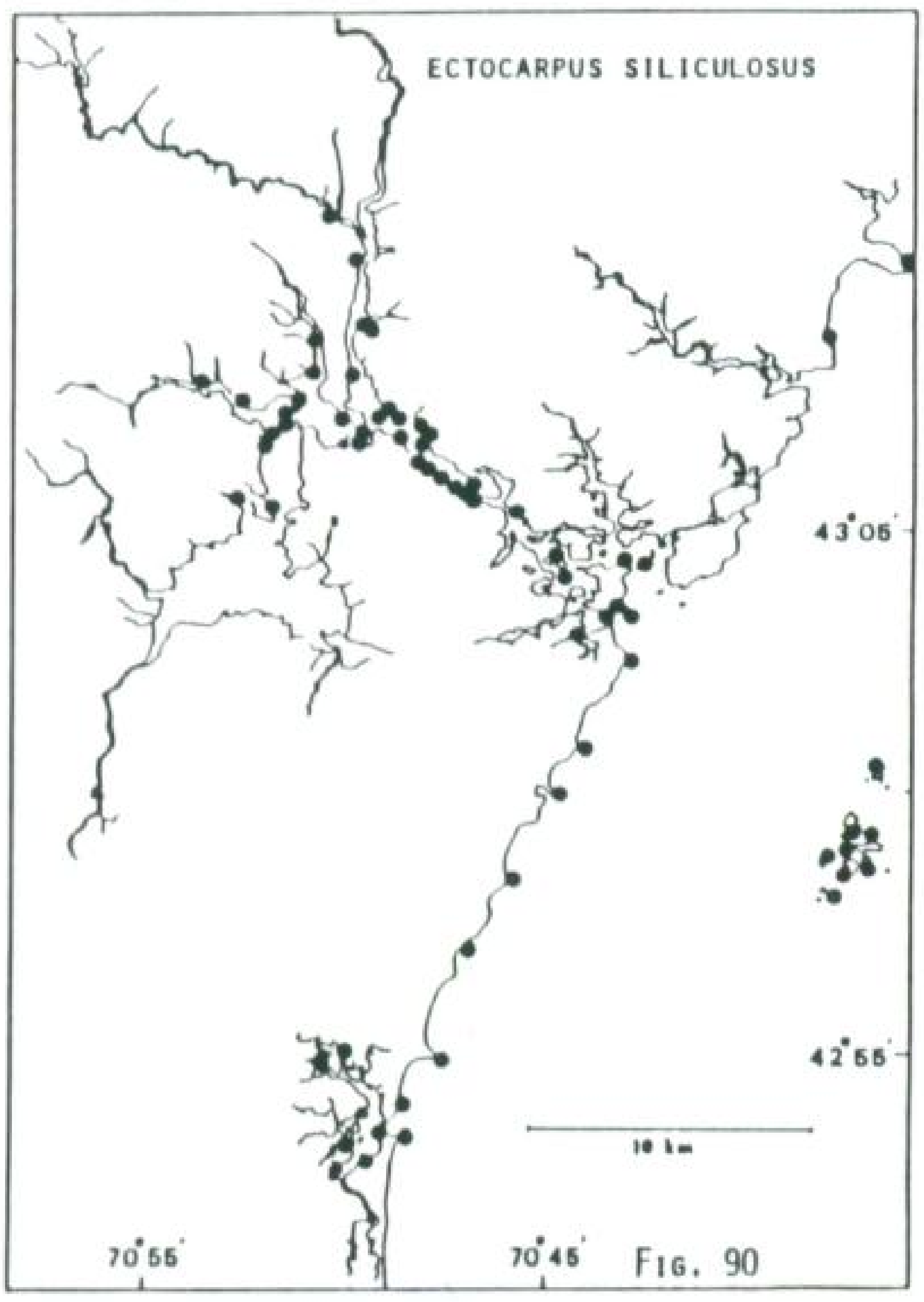


FIG. 90

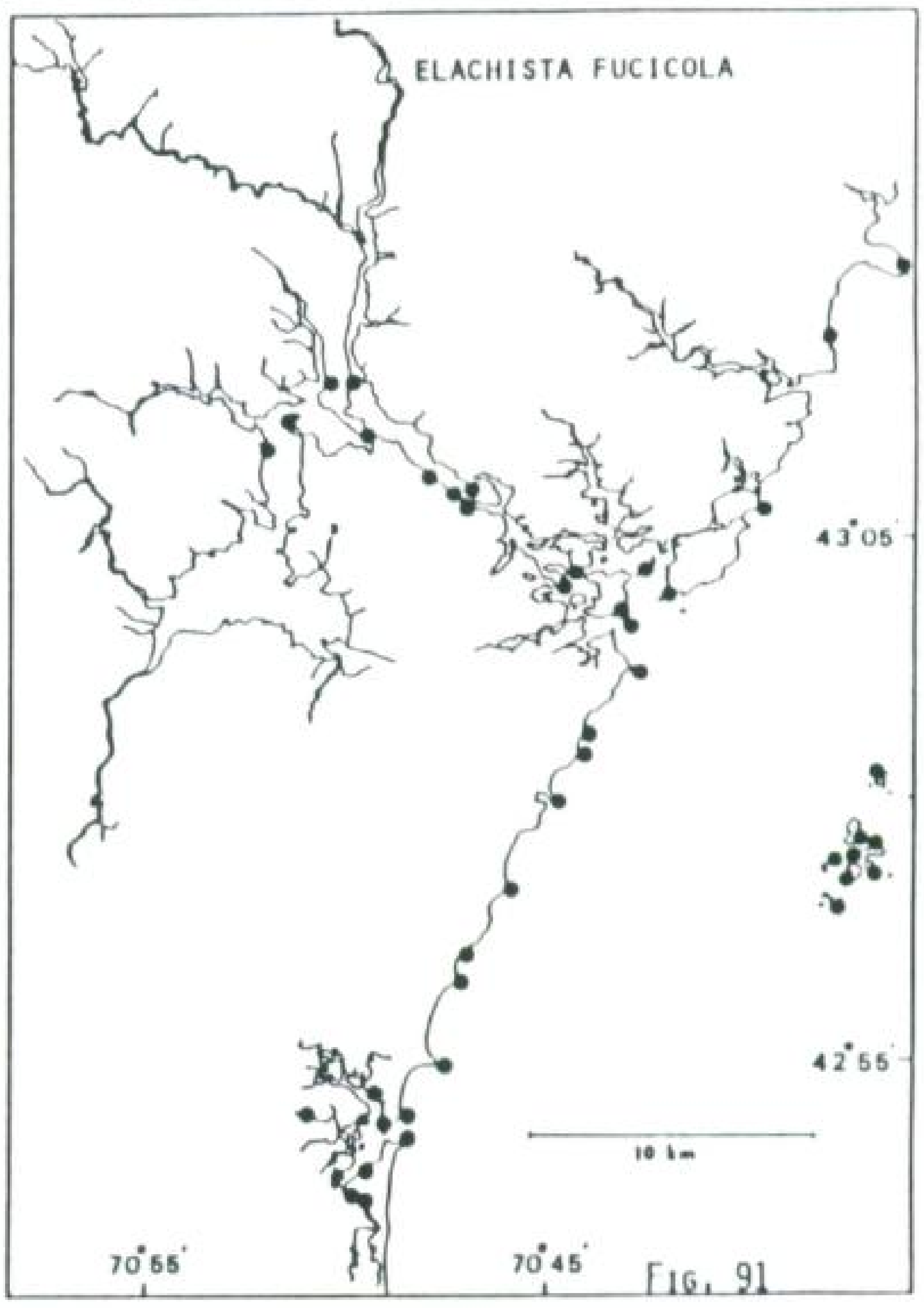


FIG. 91

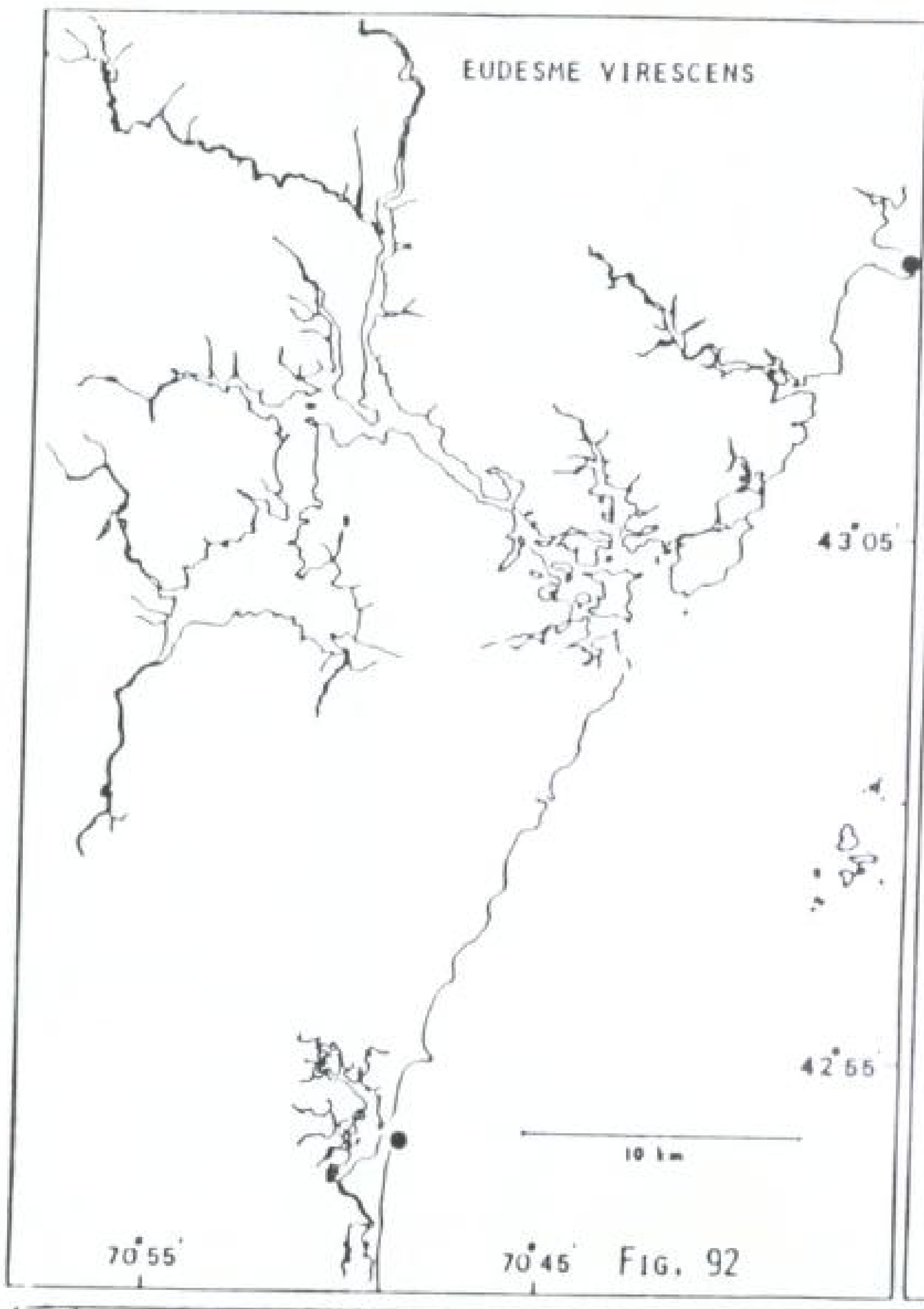


FIG. 92

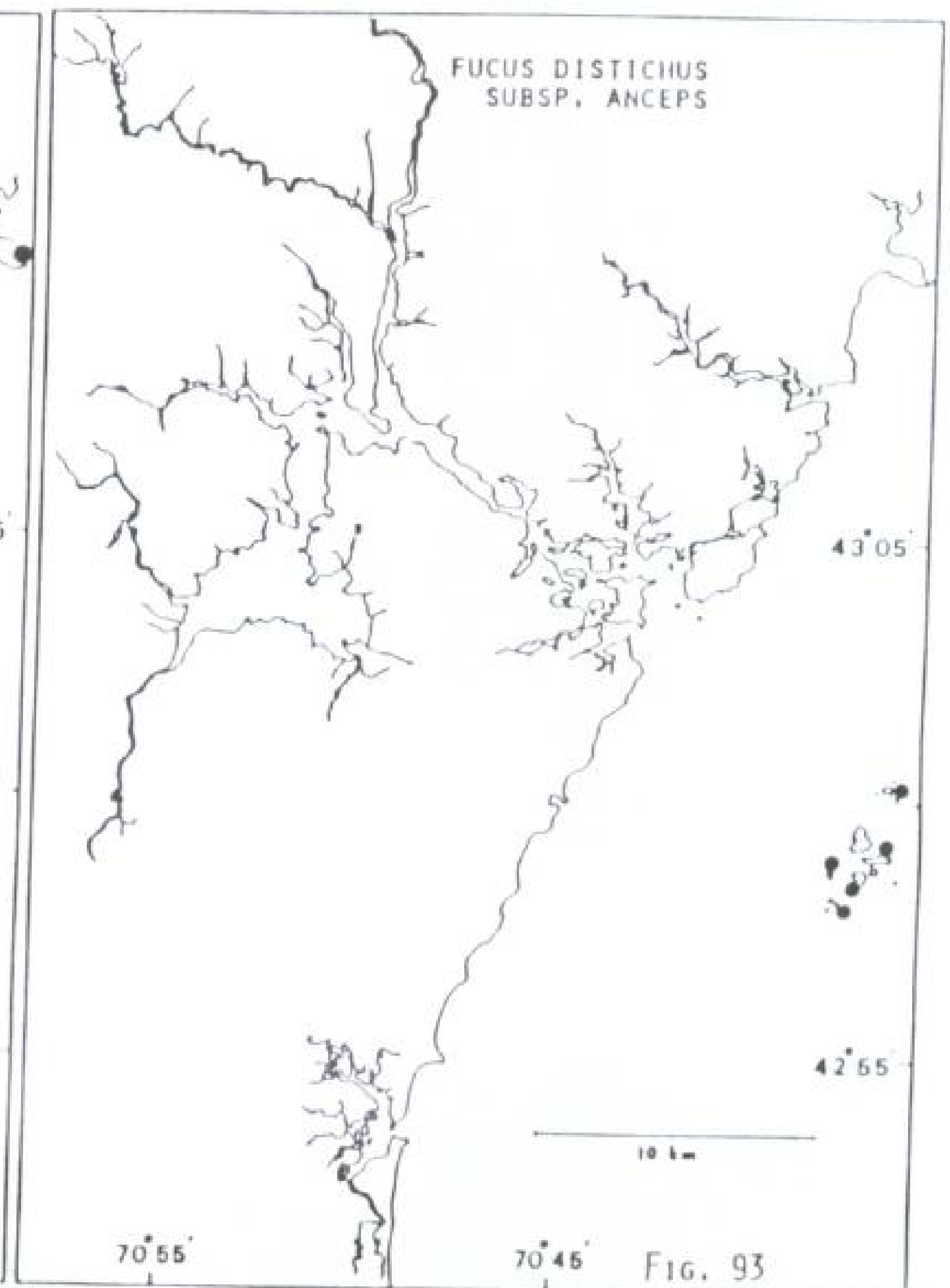


FIG. 93

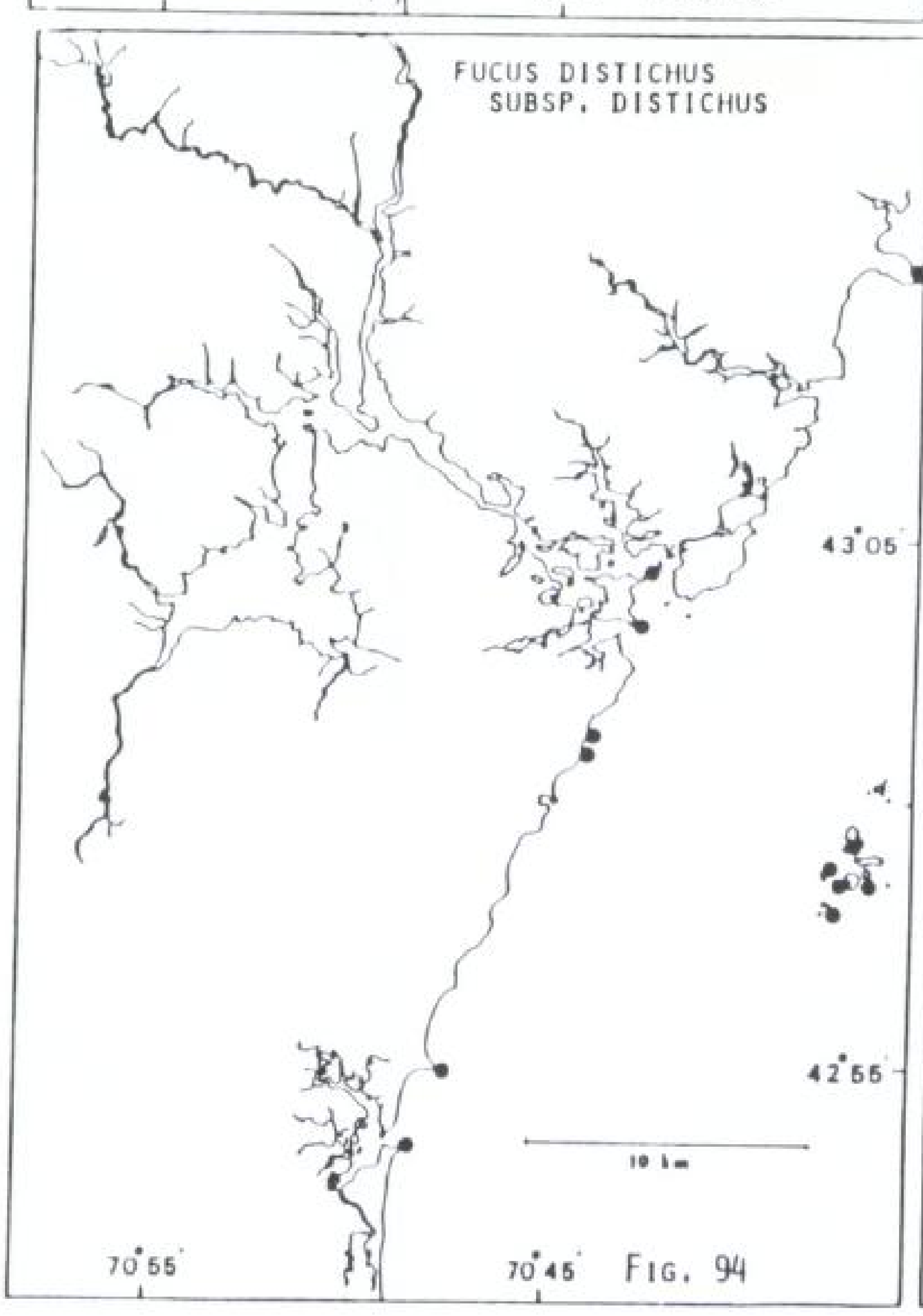


FIG. 94

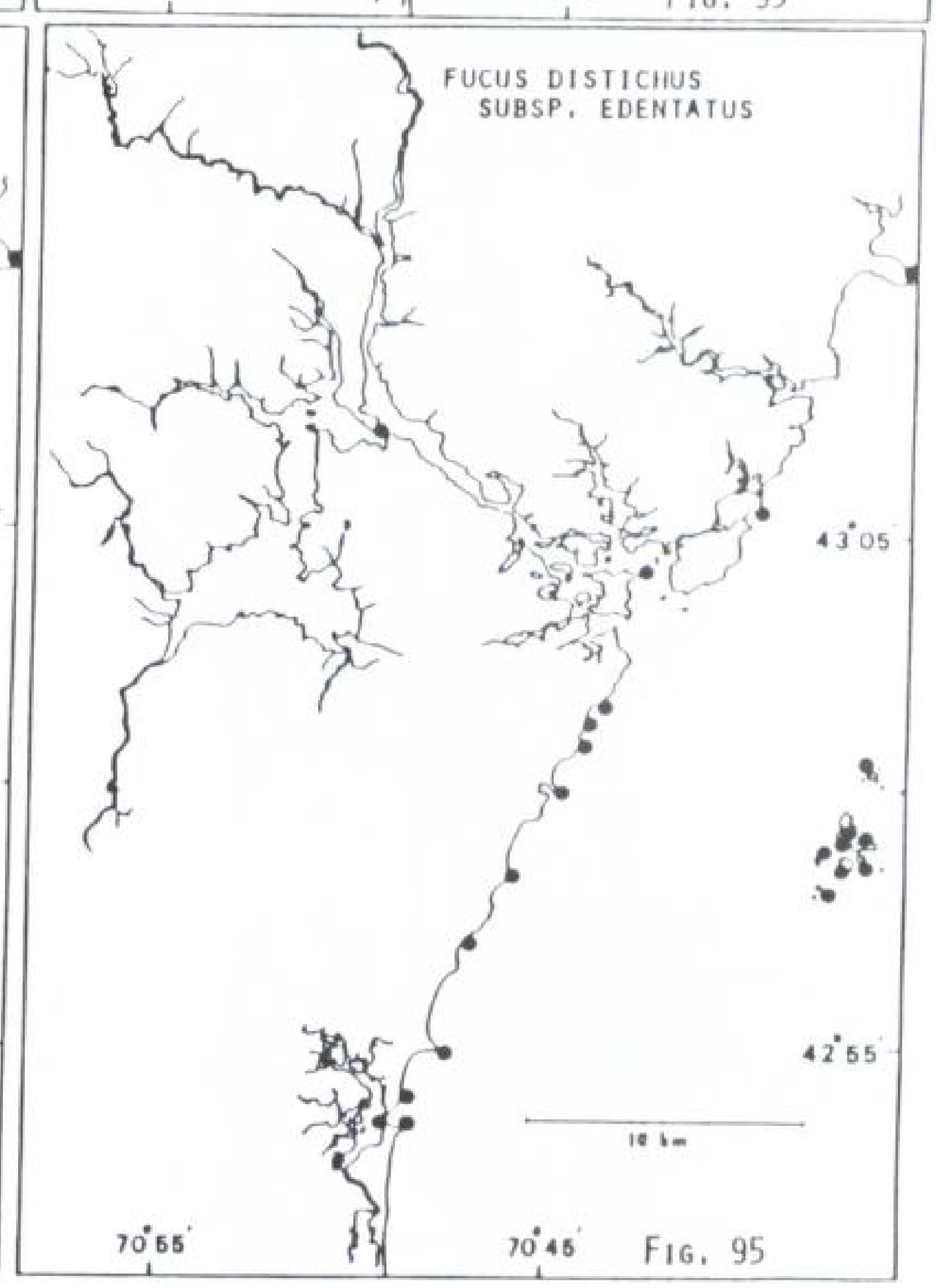


FIG. 95

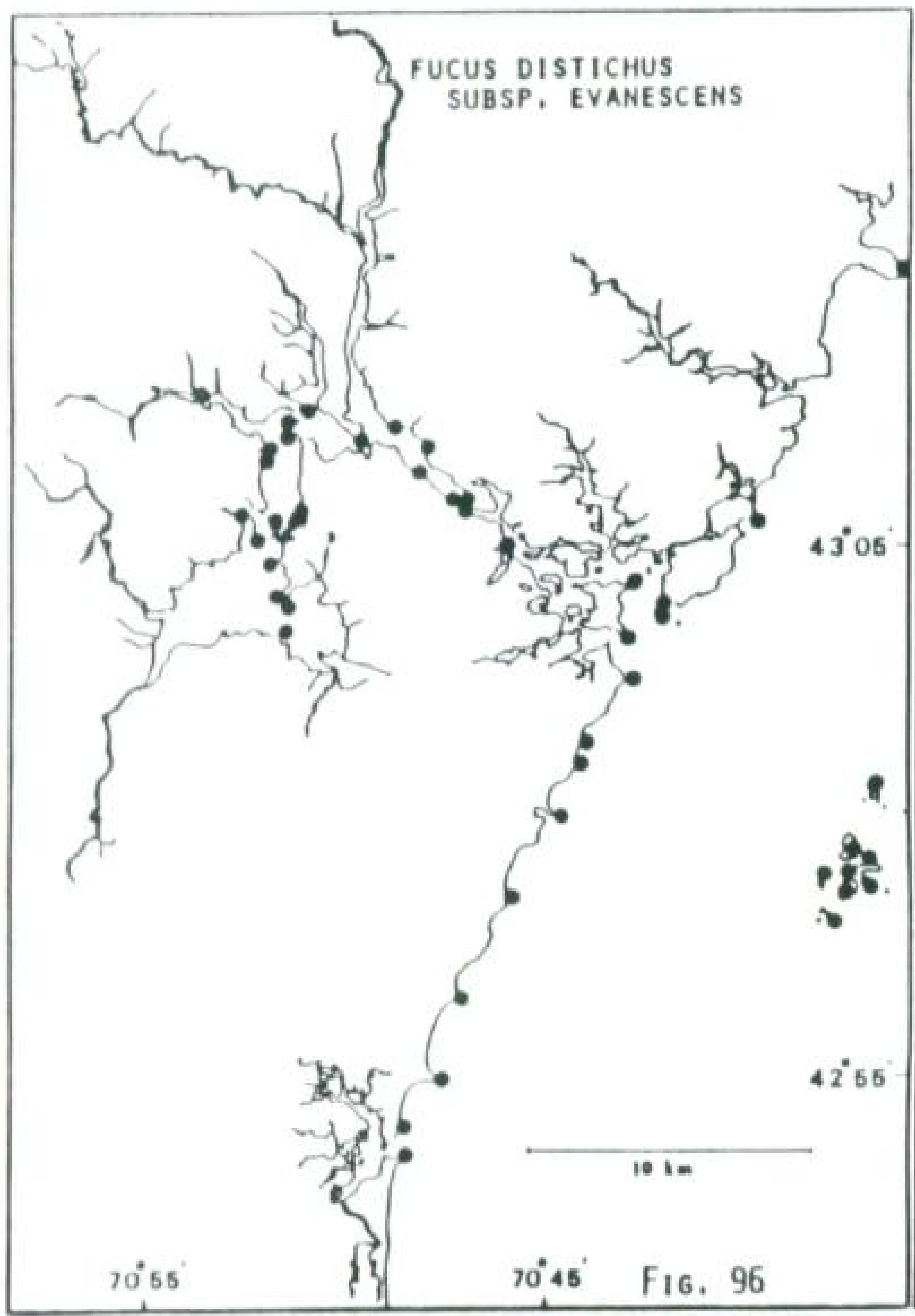


FIG. 96

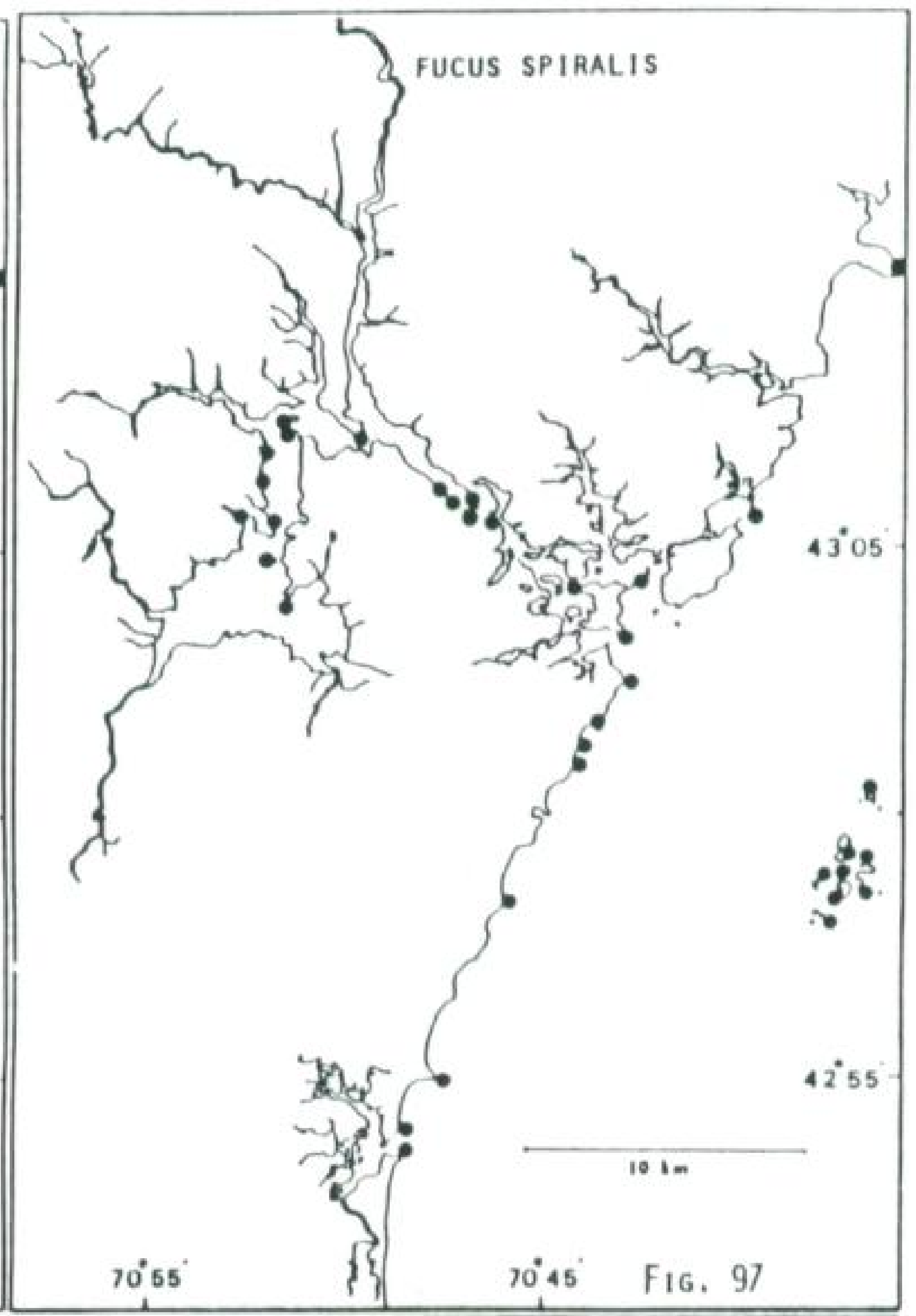


FIG. 97

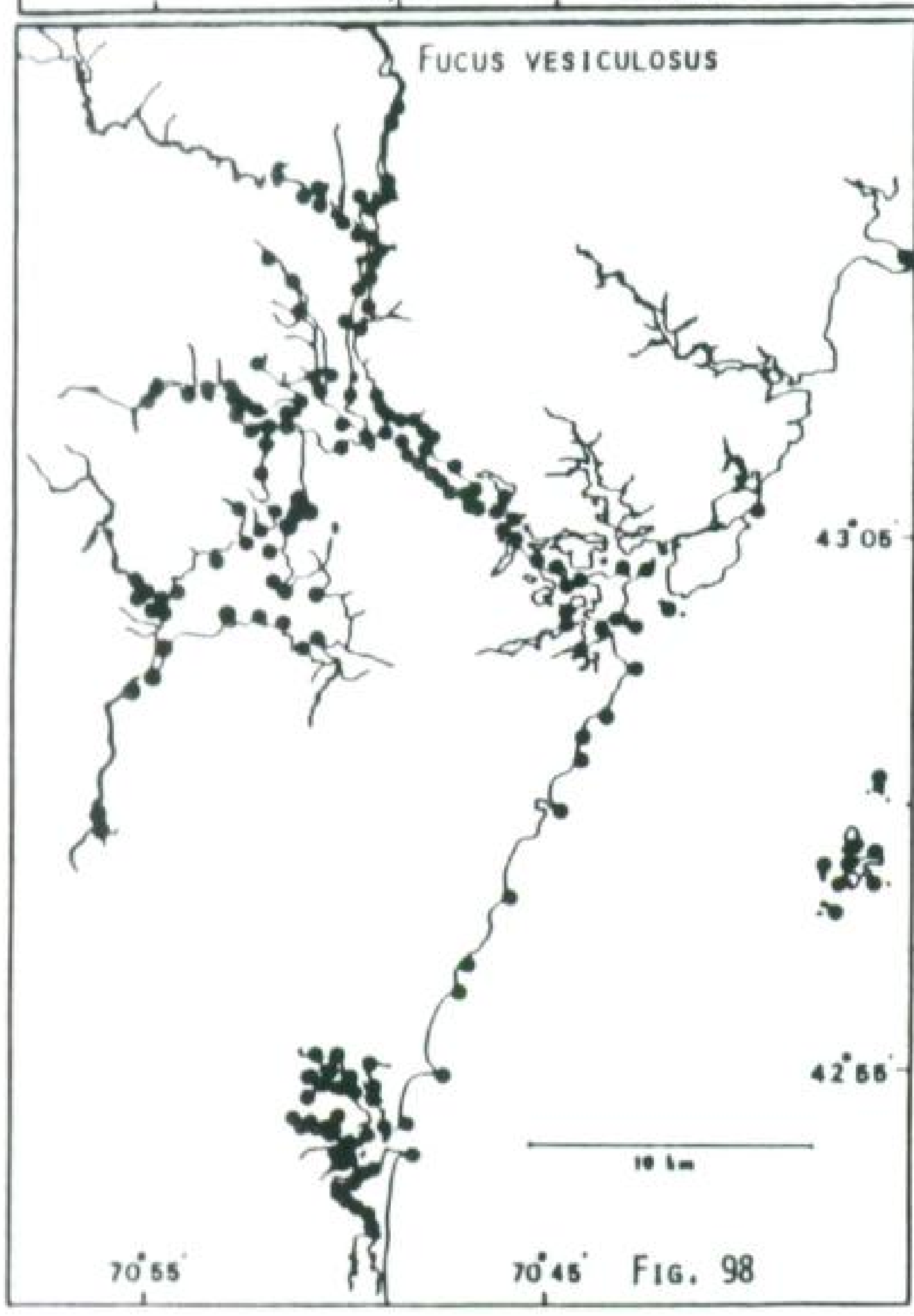


FIG. 98

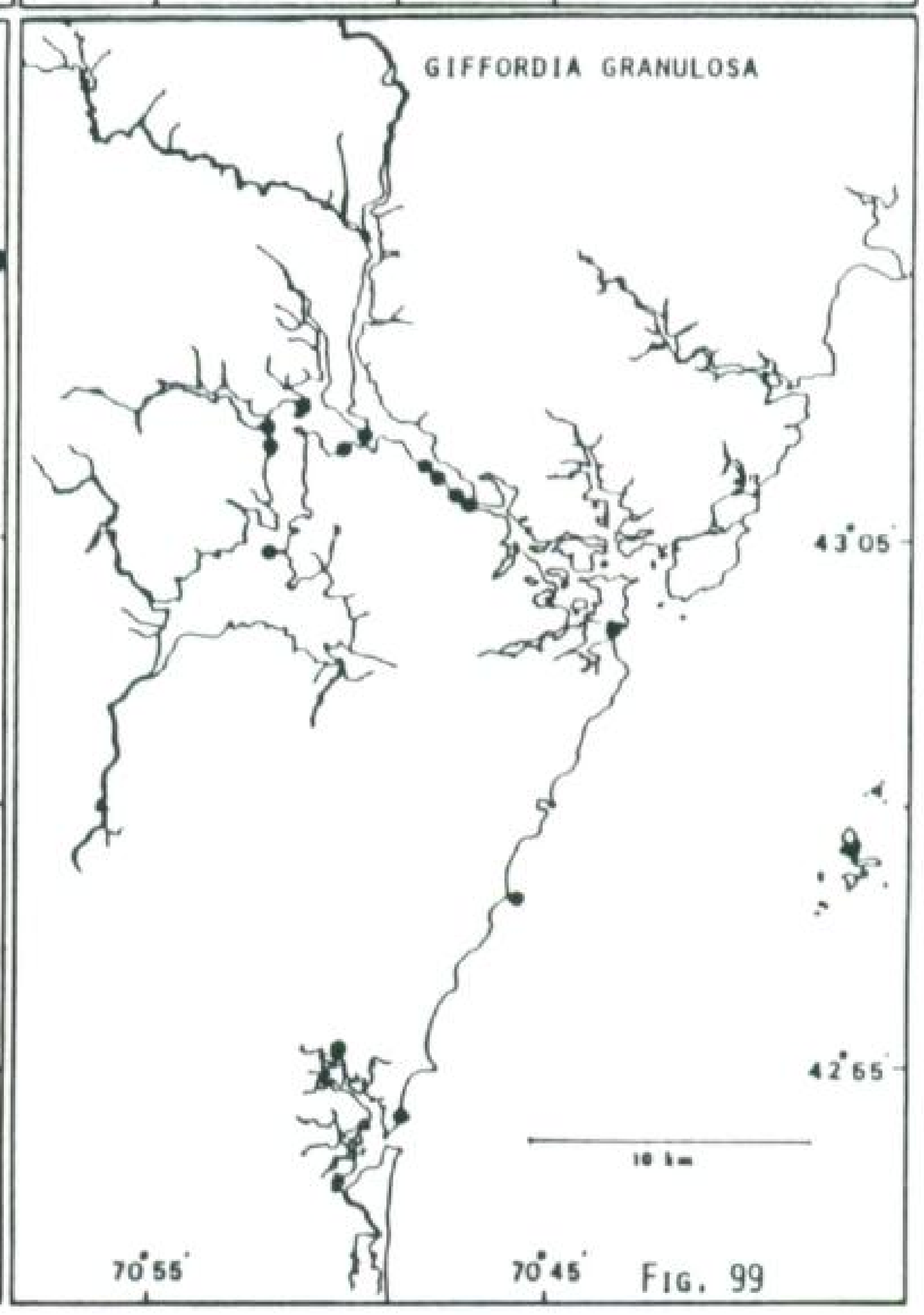


FIG. 99

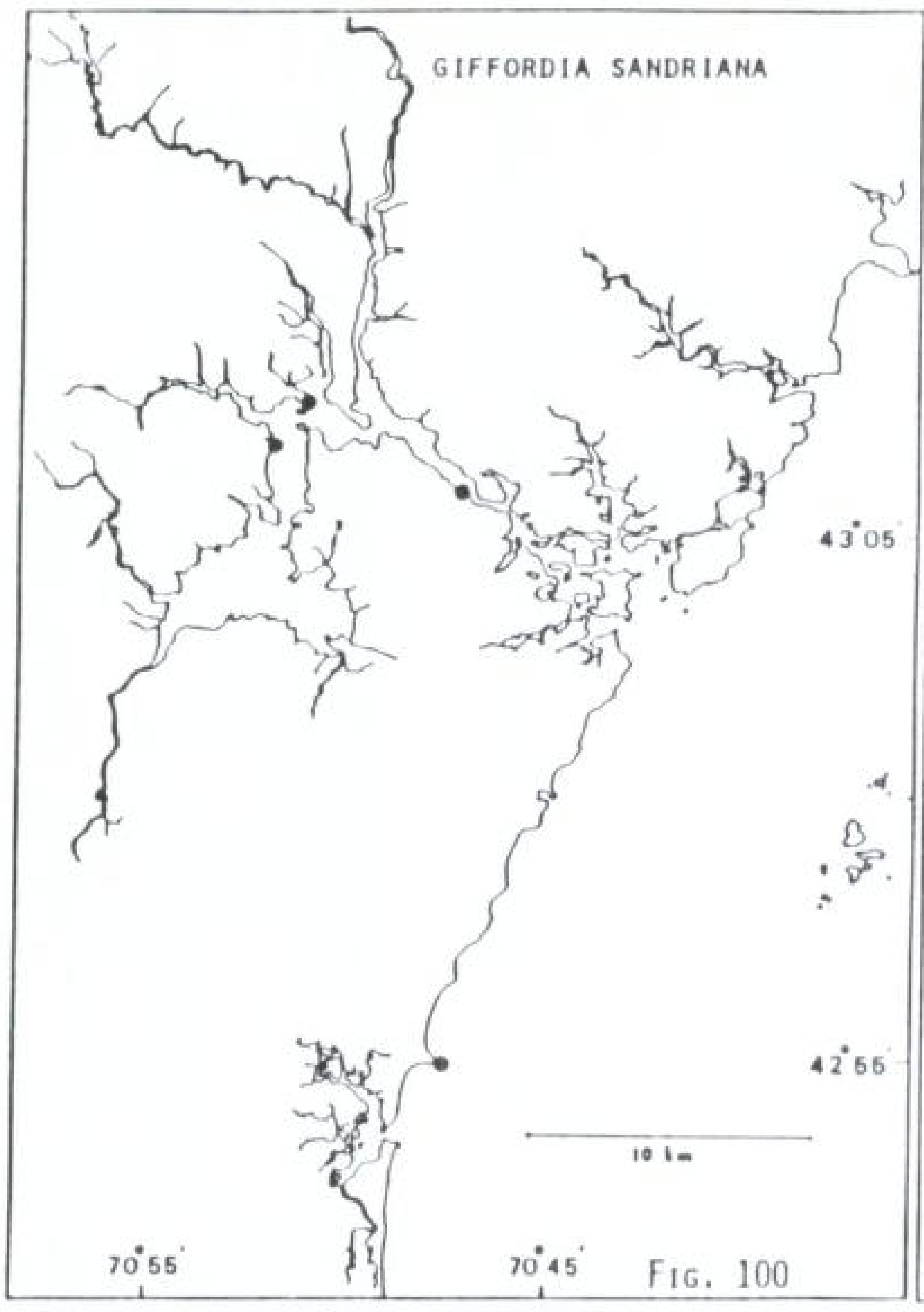


Fig. 100

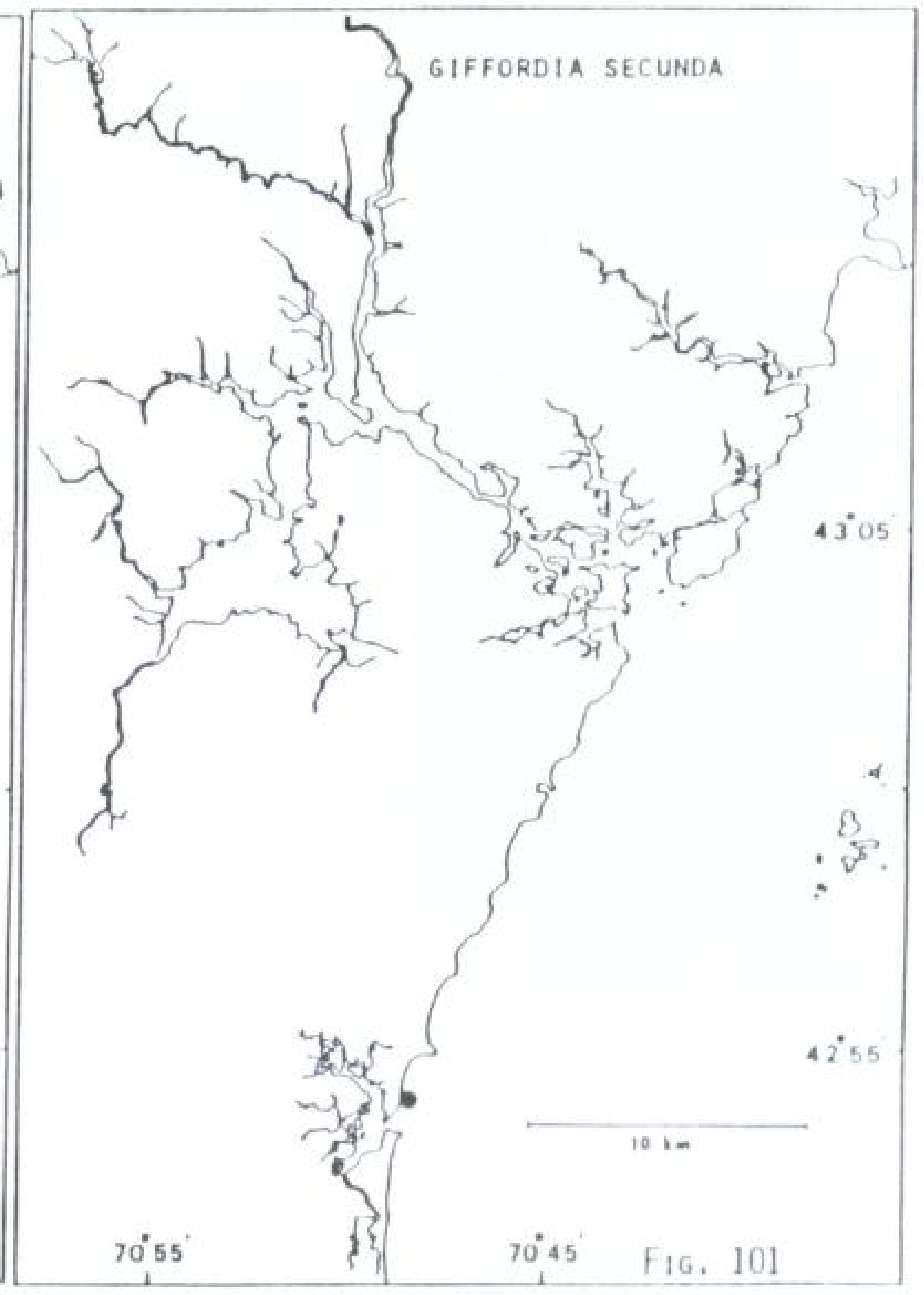


Fig. 101

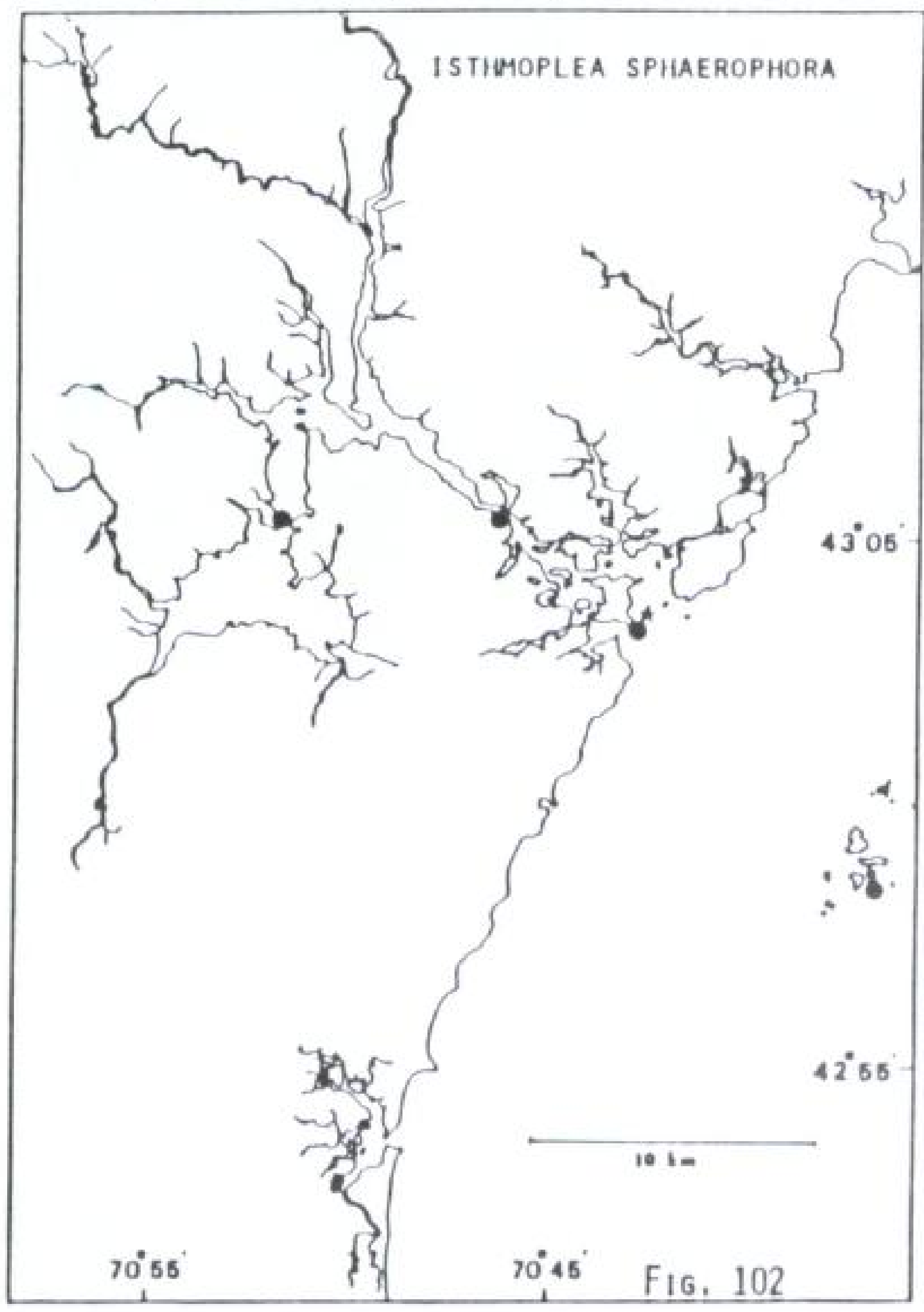


Fig. 102

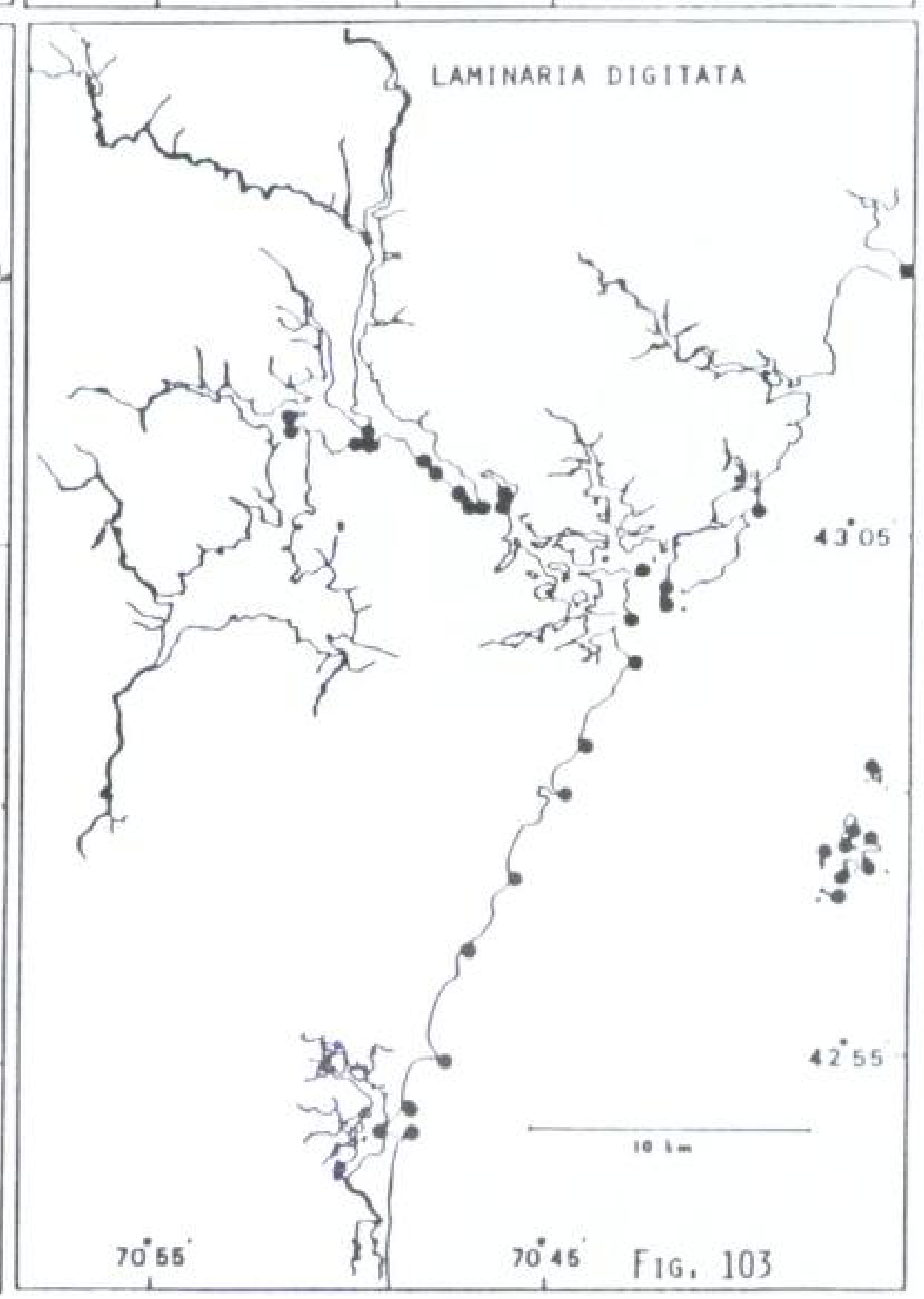


Fig. 103

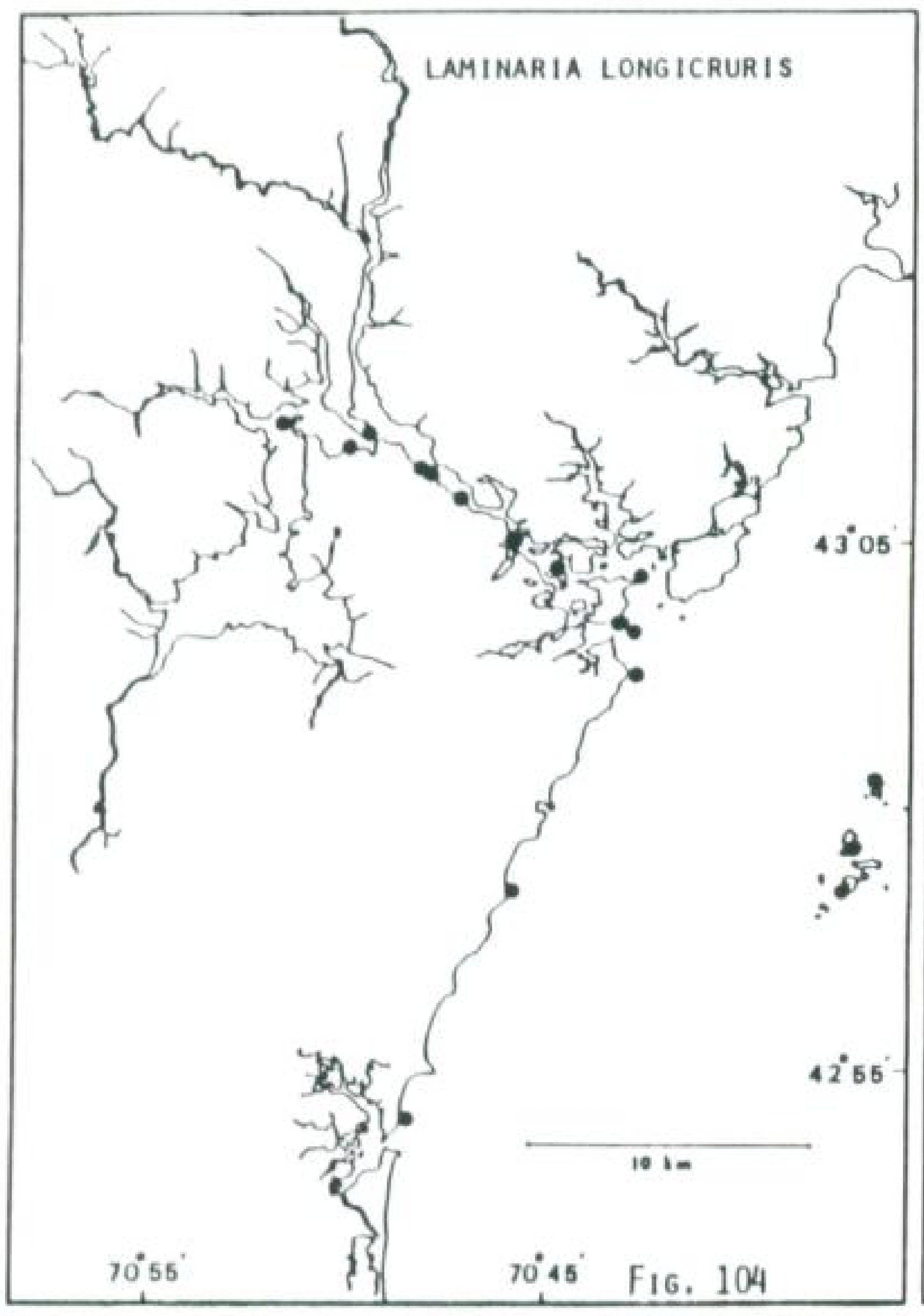


FIG. 104

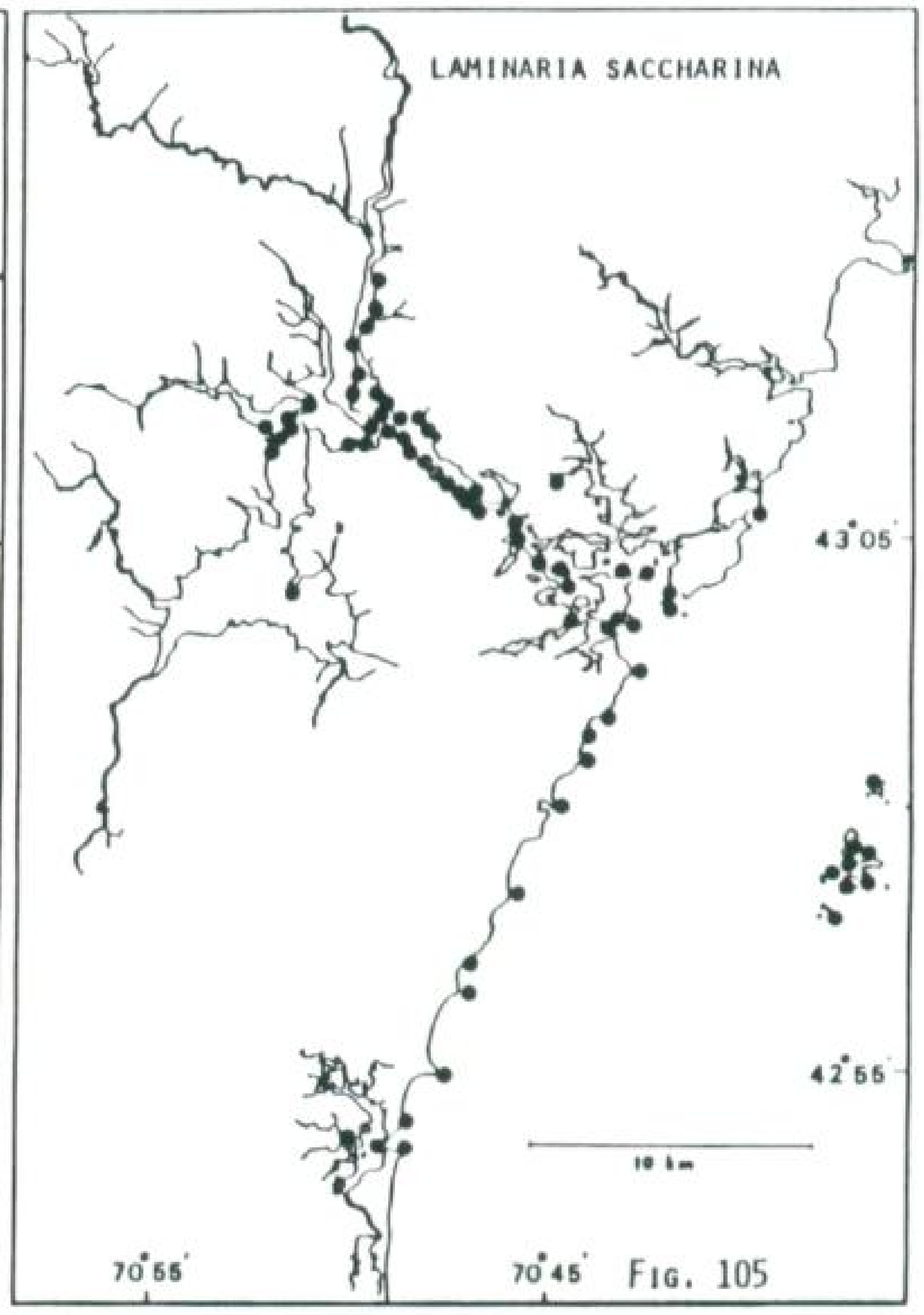


FIG. 105

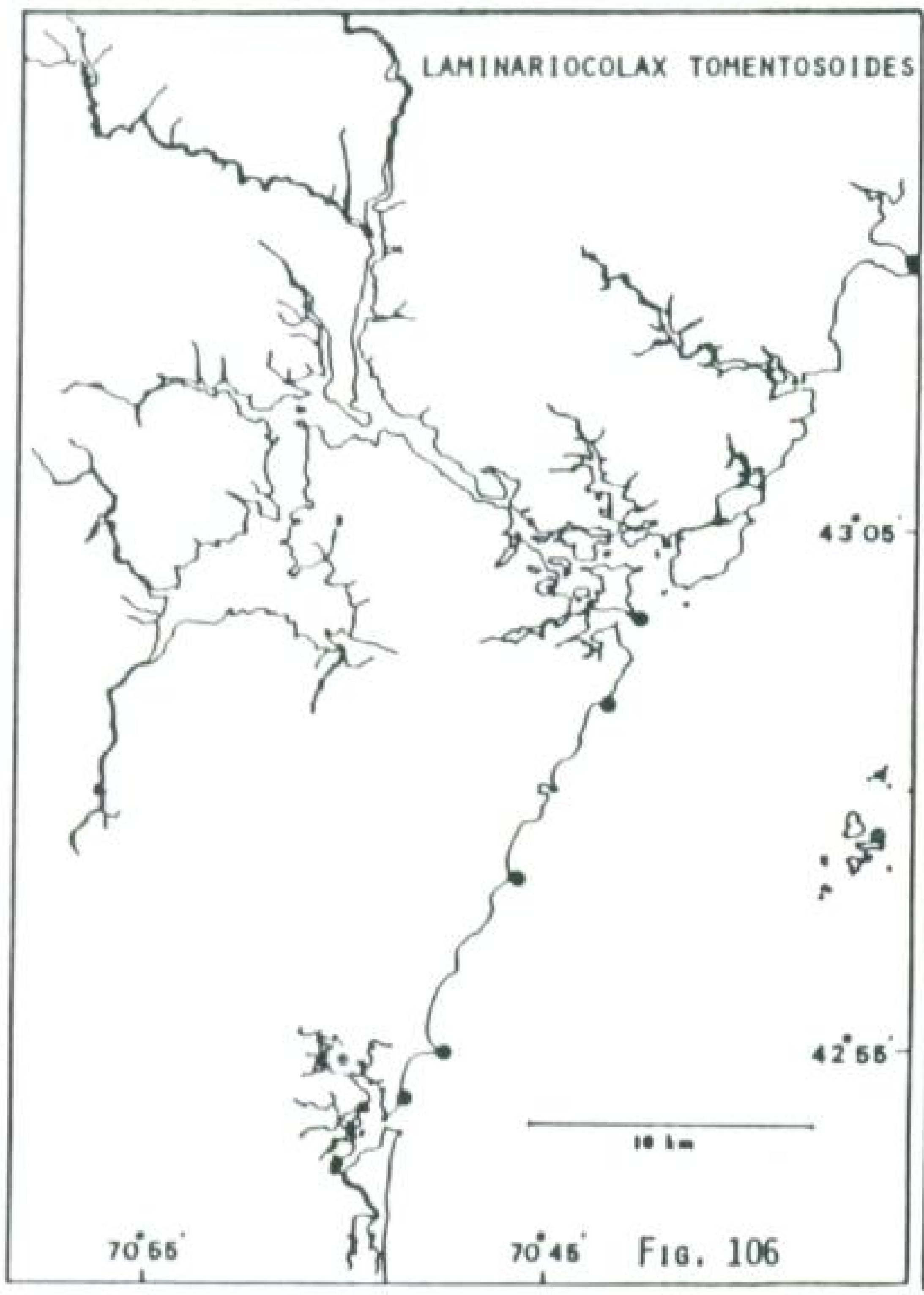


FIG. 106

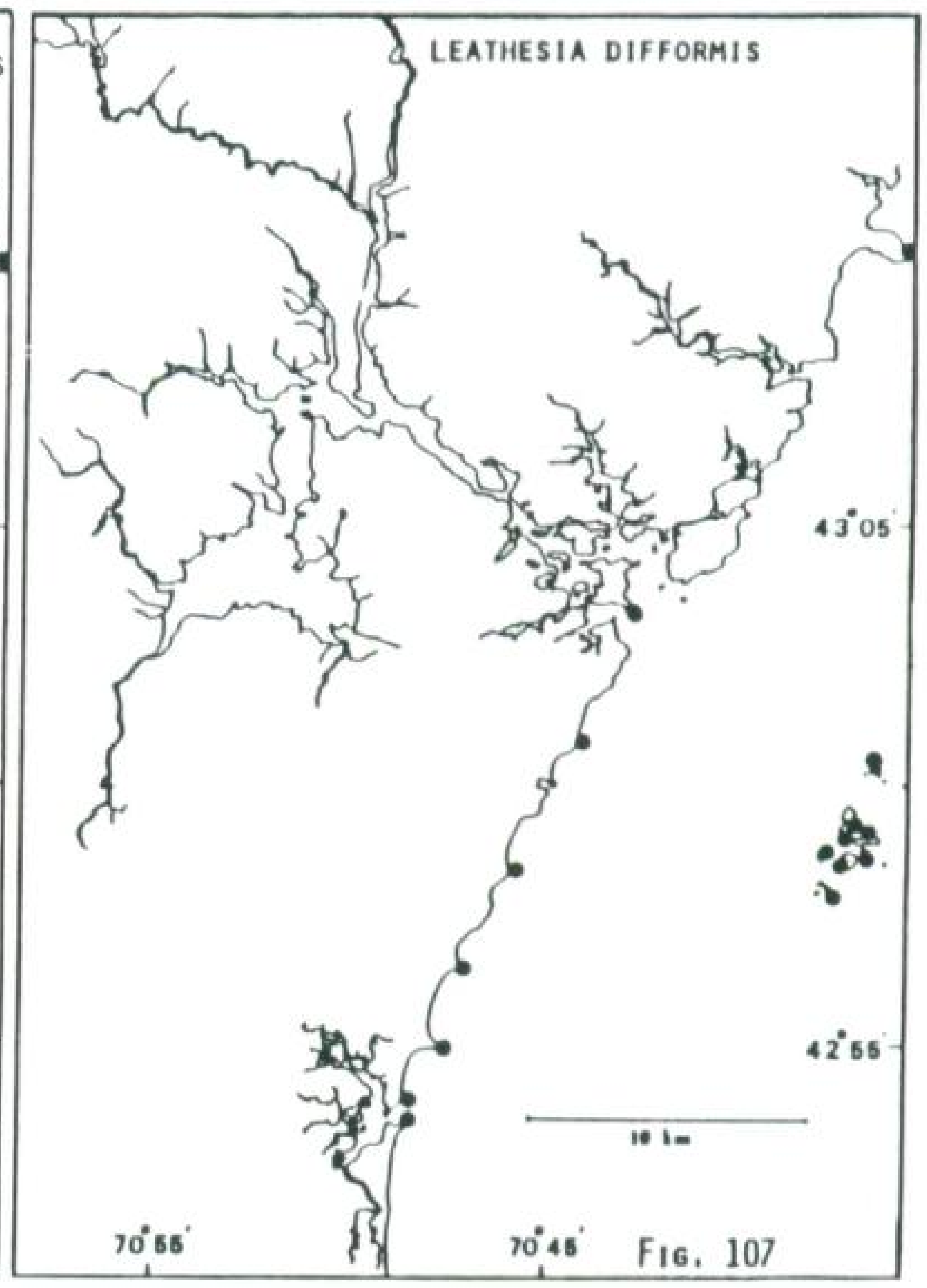


FIG. 107

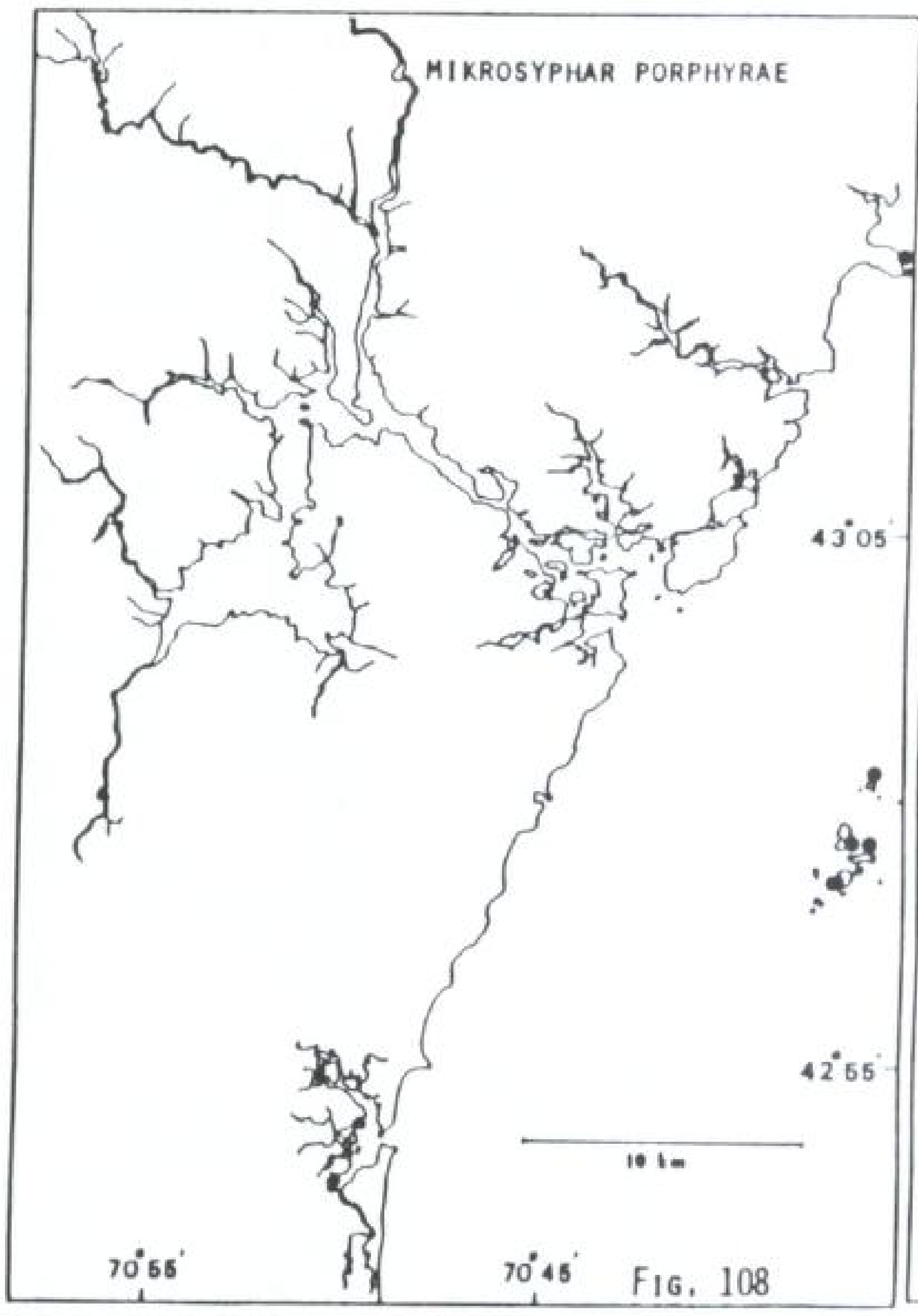


Fig. 108

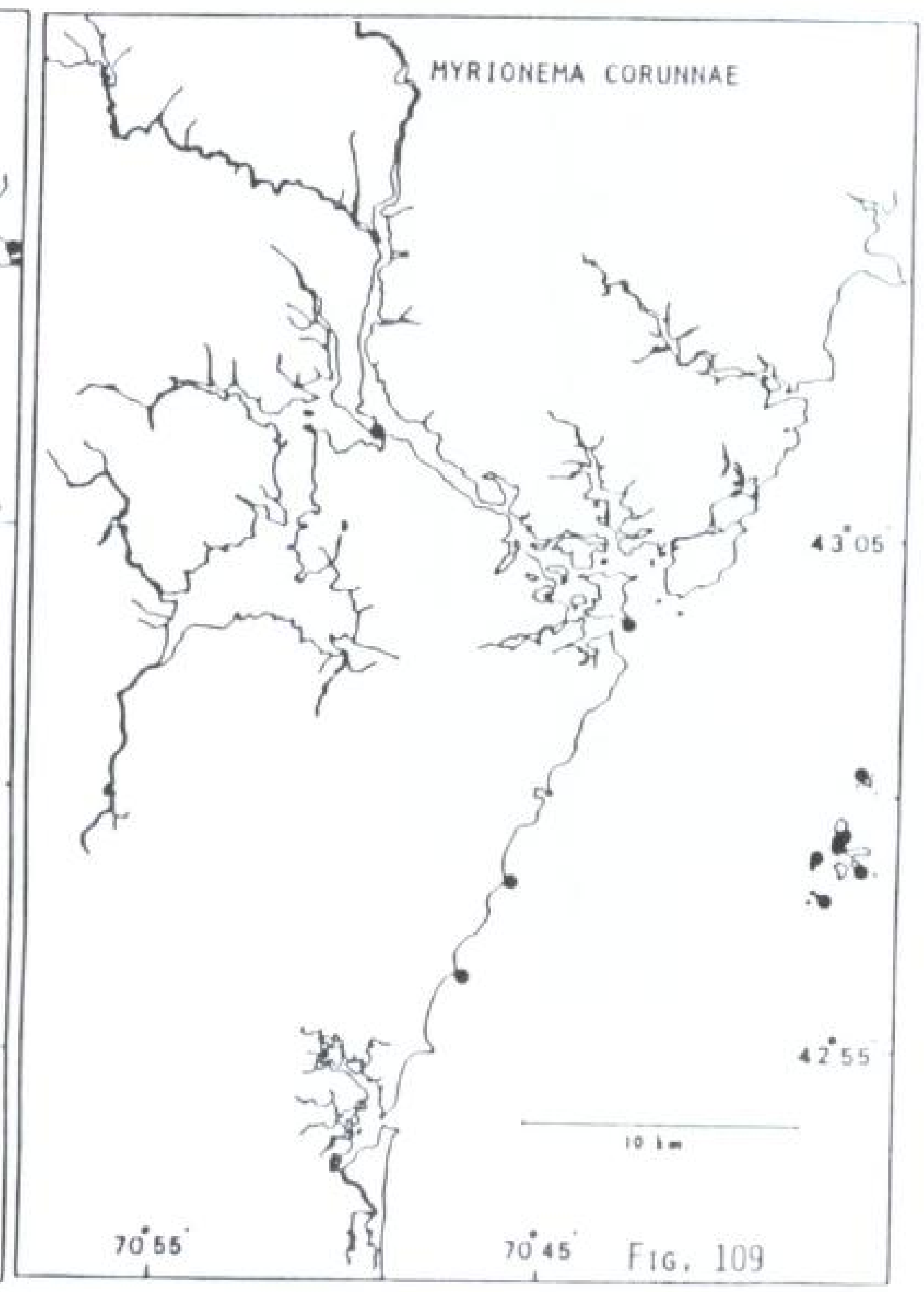


Fig. 109

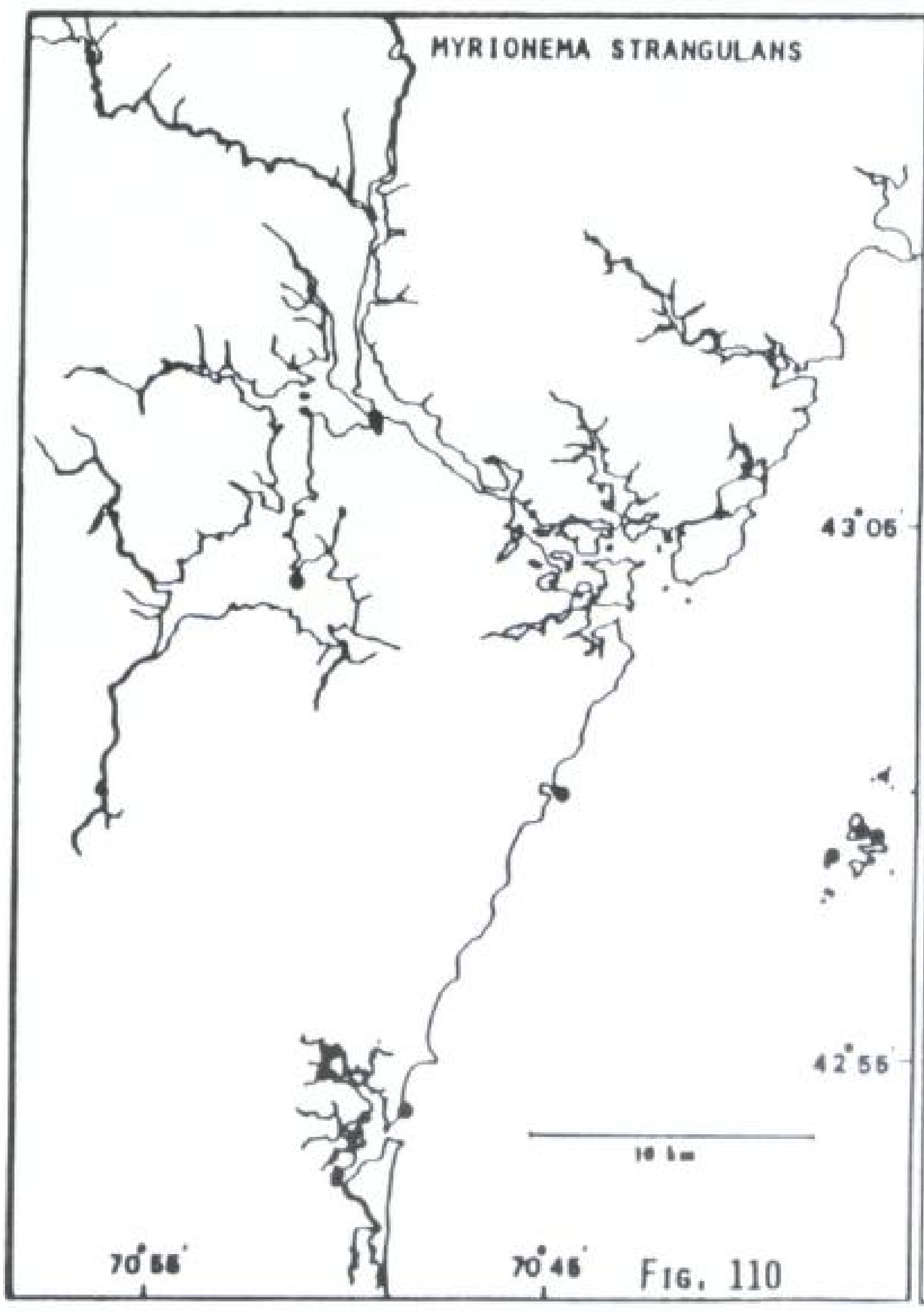


Fig. 110

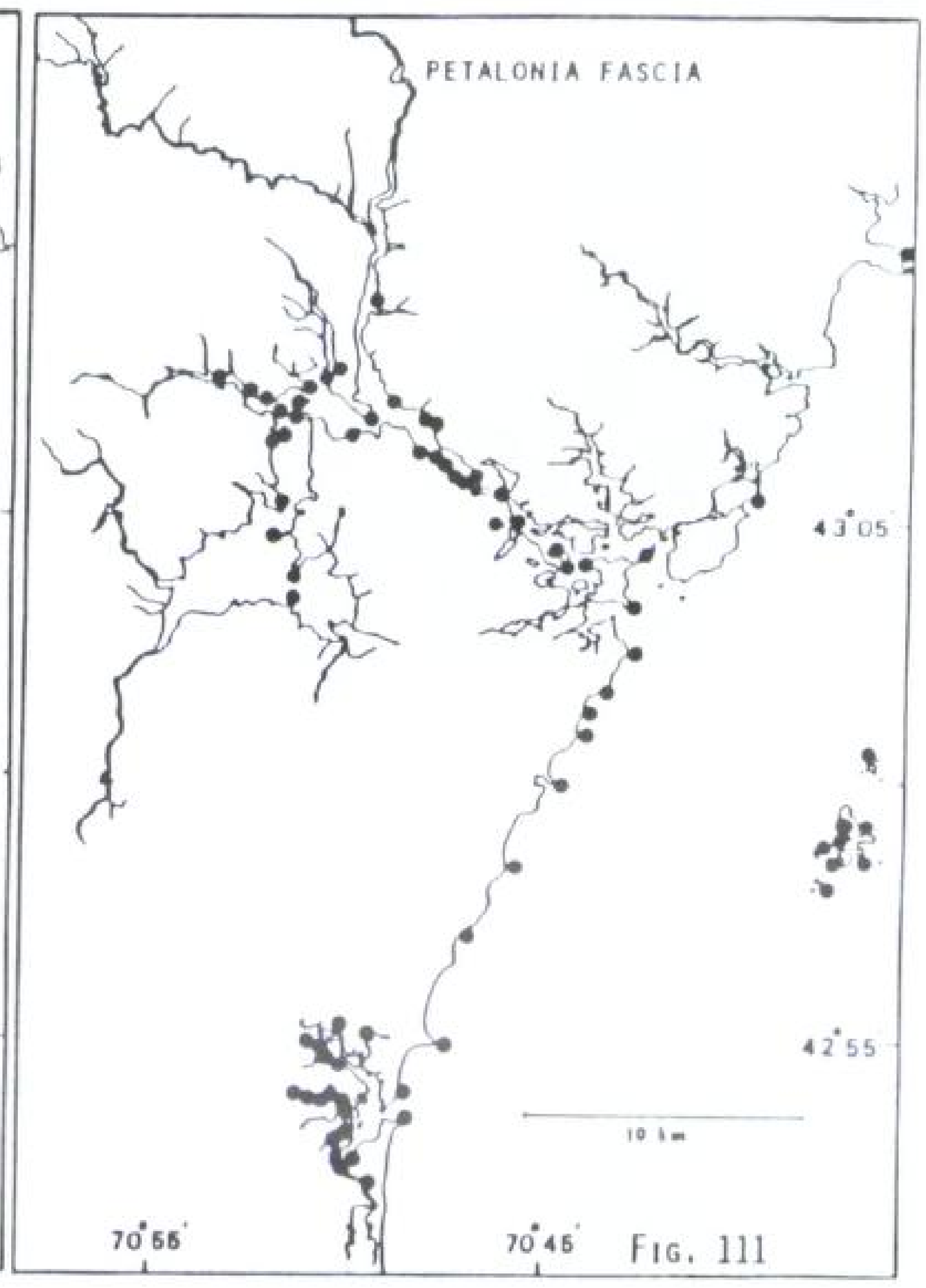


Fig. 111

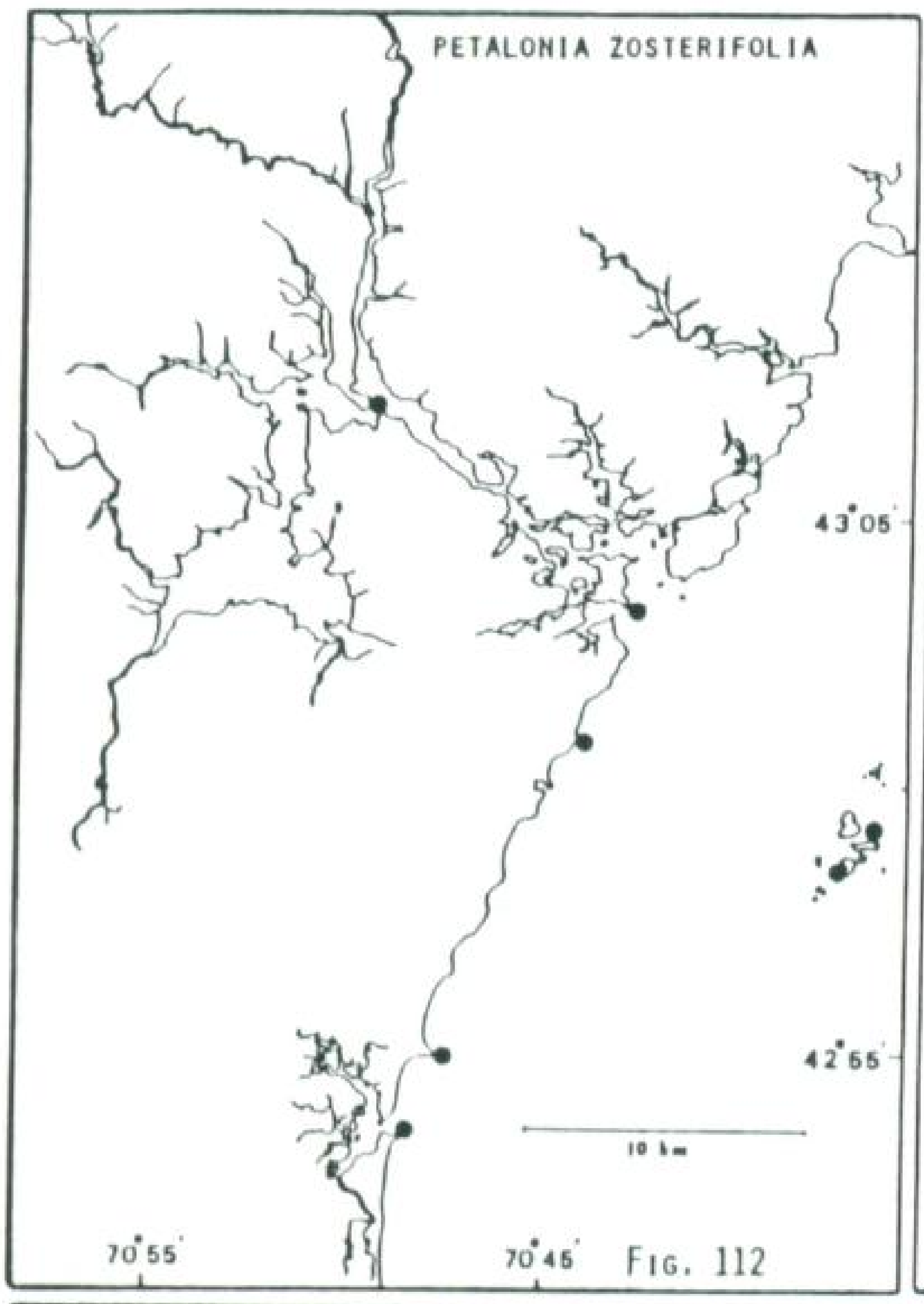


Fig. 112

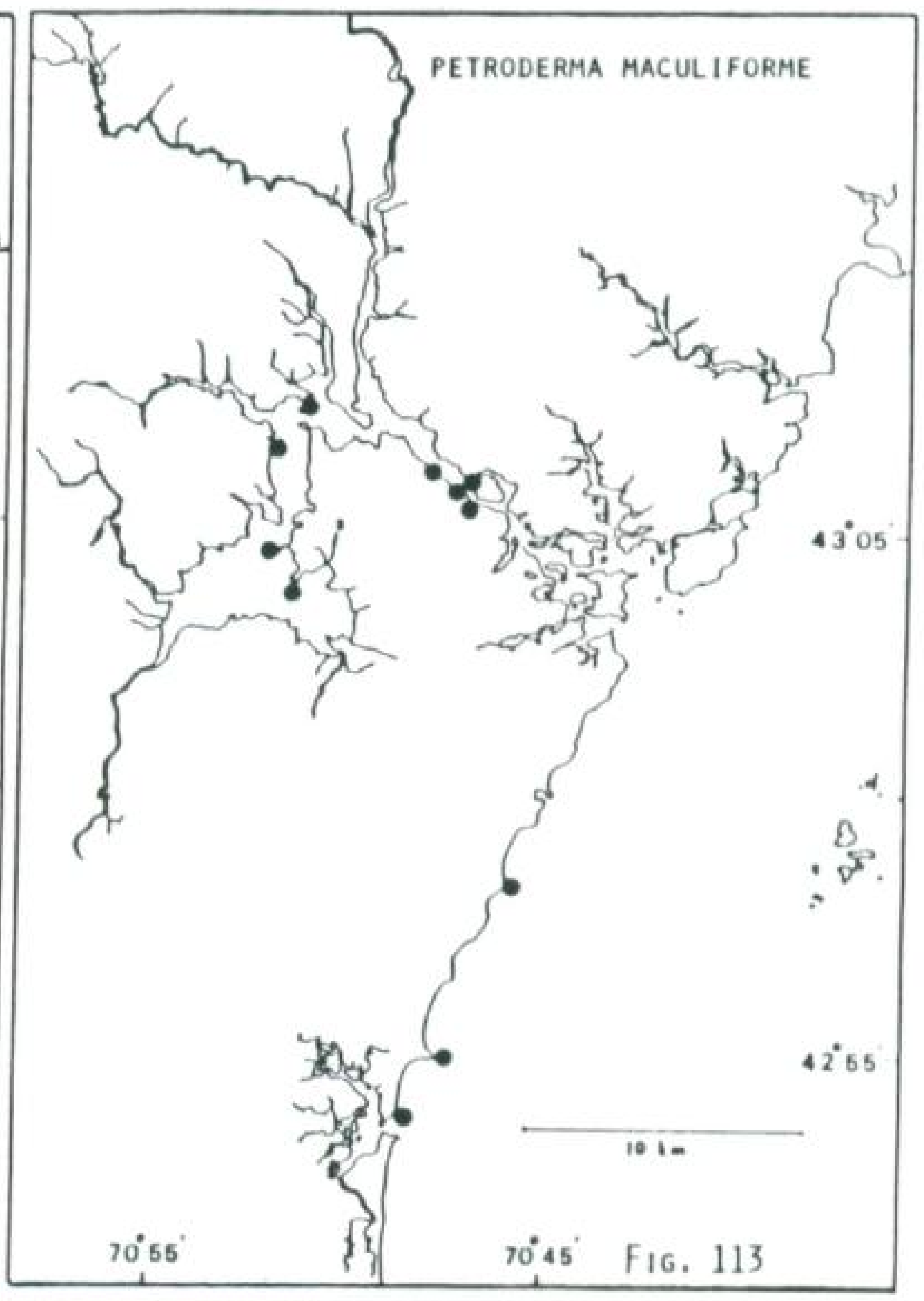


Fig. 113

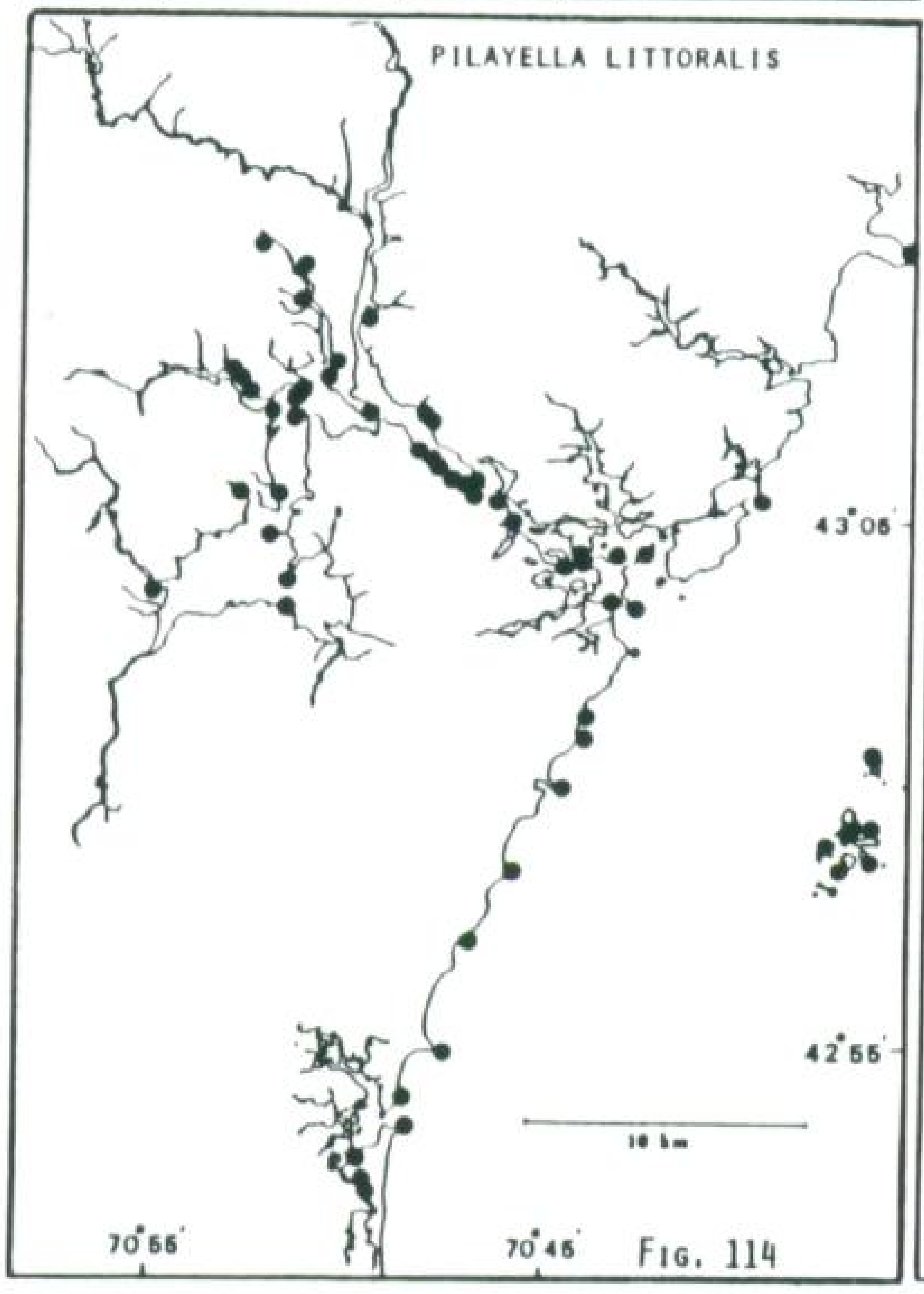


Fig. 114

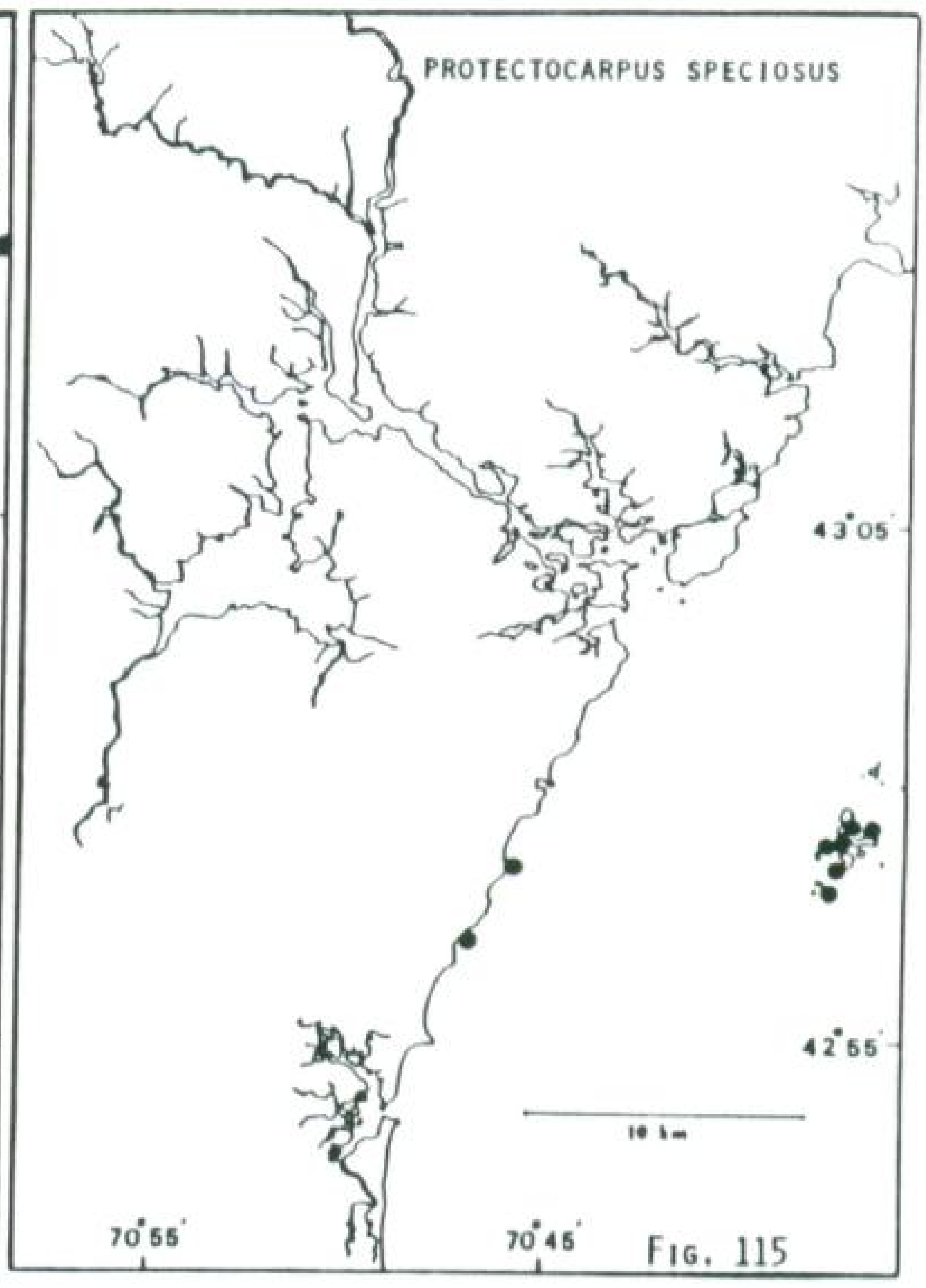


Fig. 115

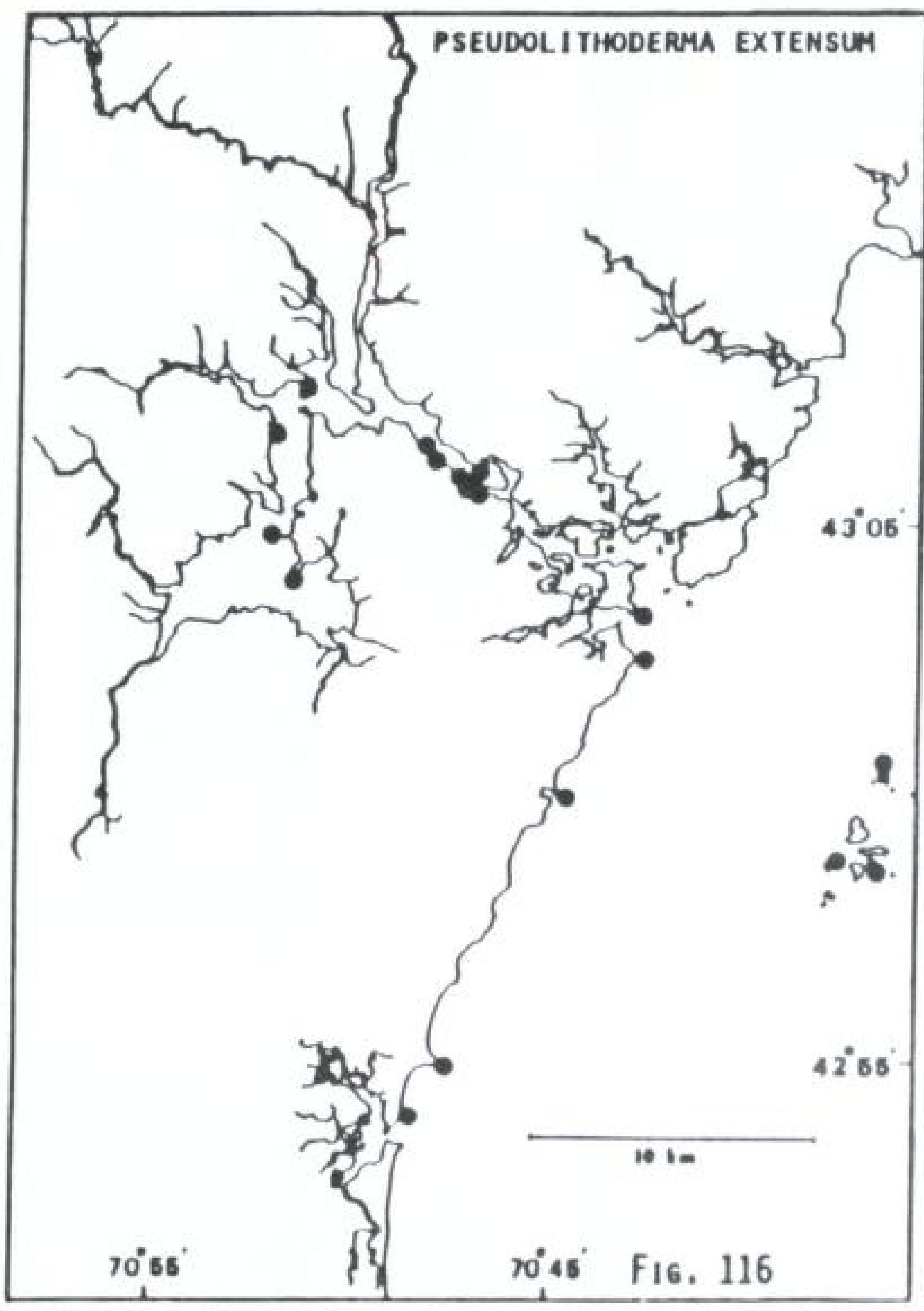


Fig. 116

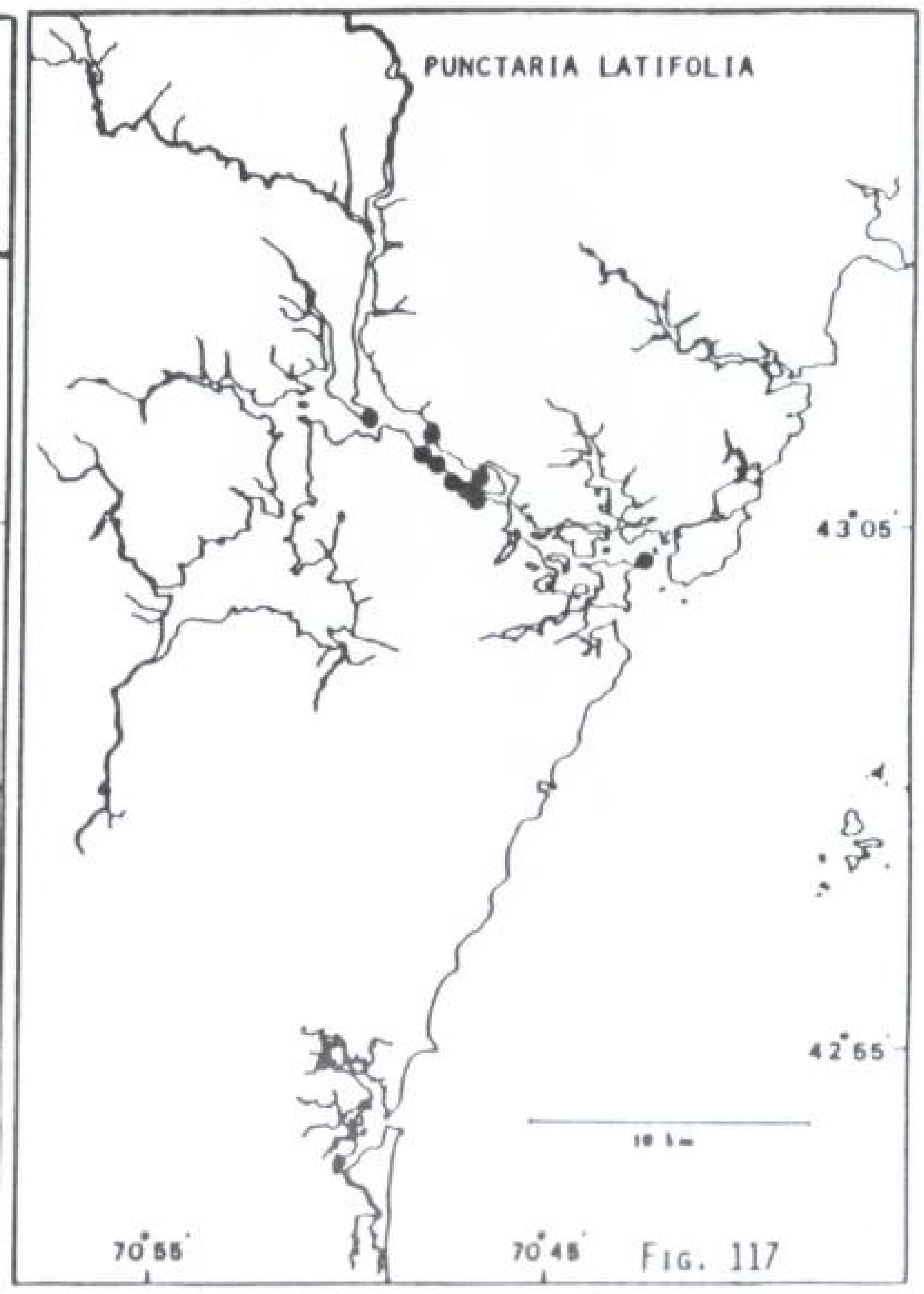


Fig. 117

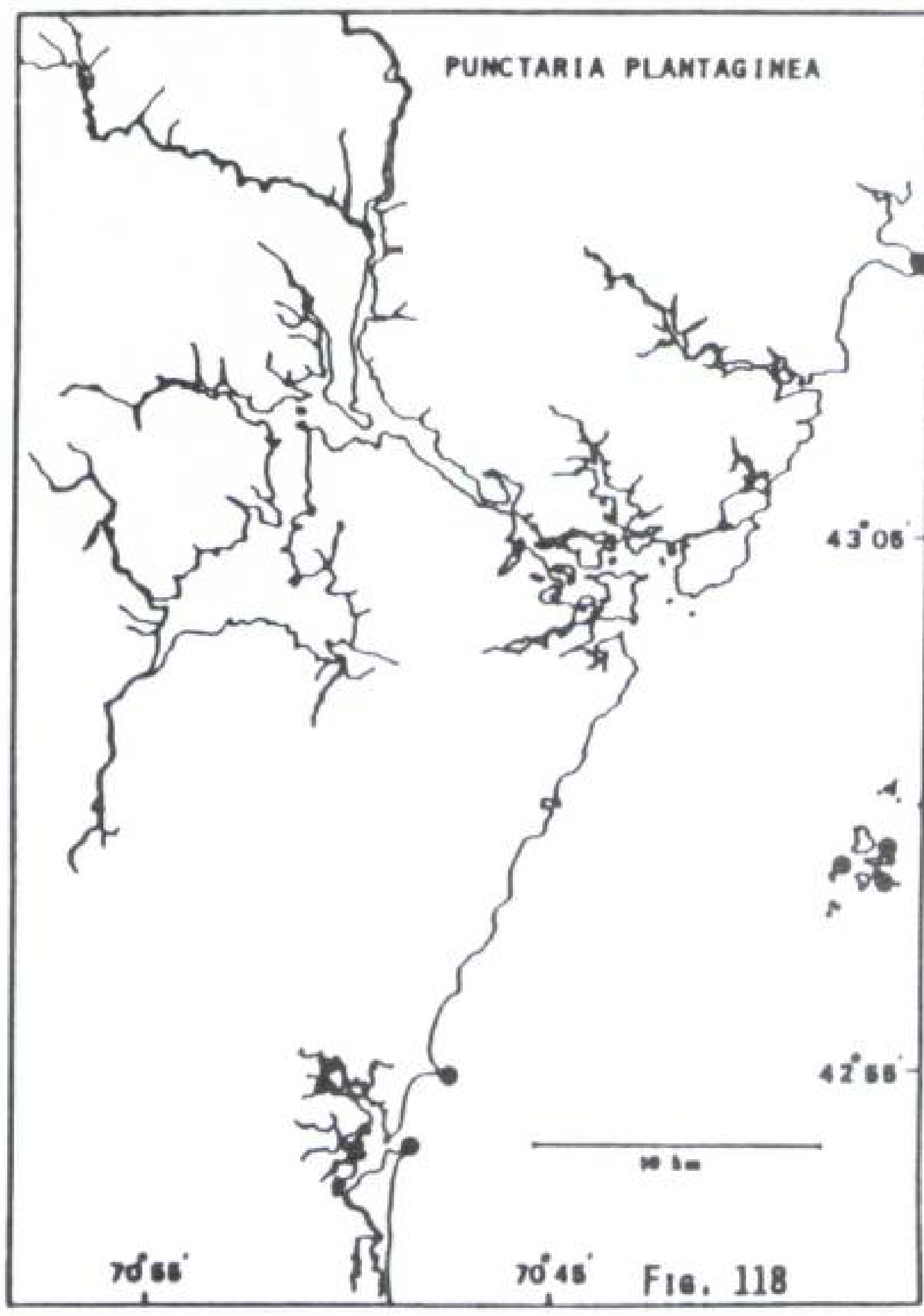


Fig. 118

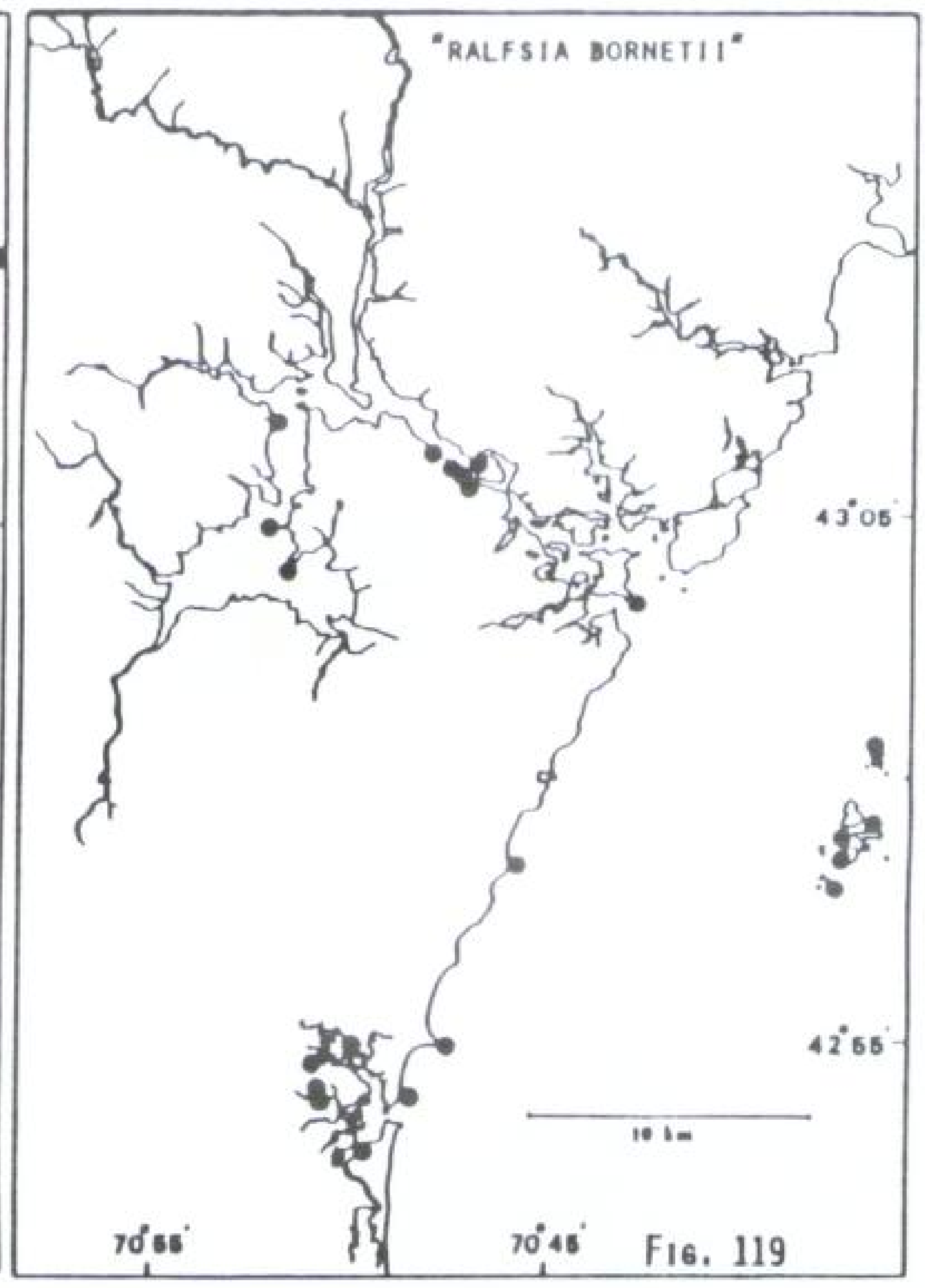


Fig. 119

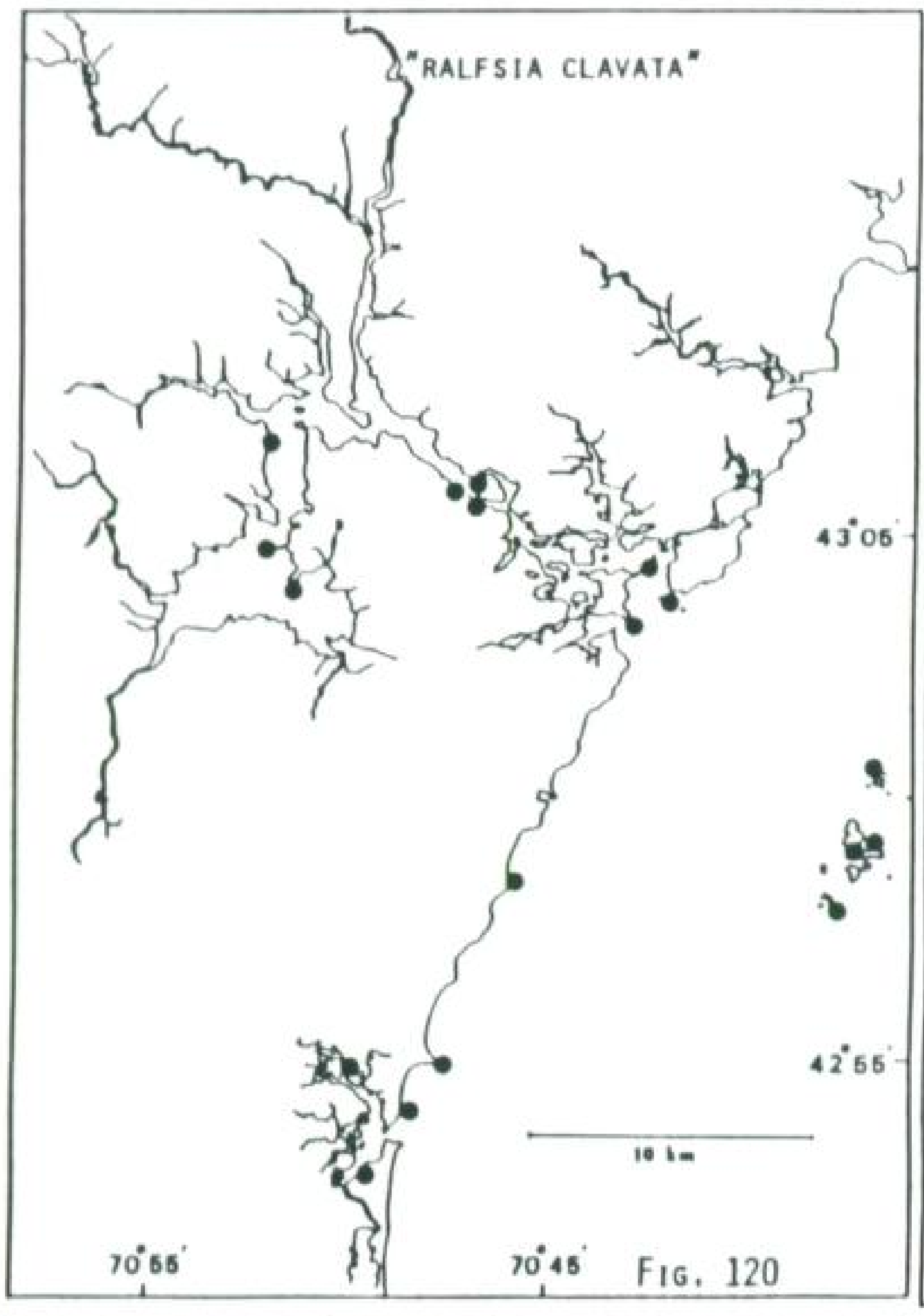


Fig. 120

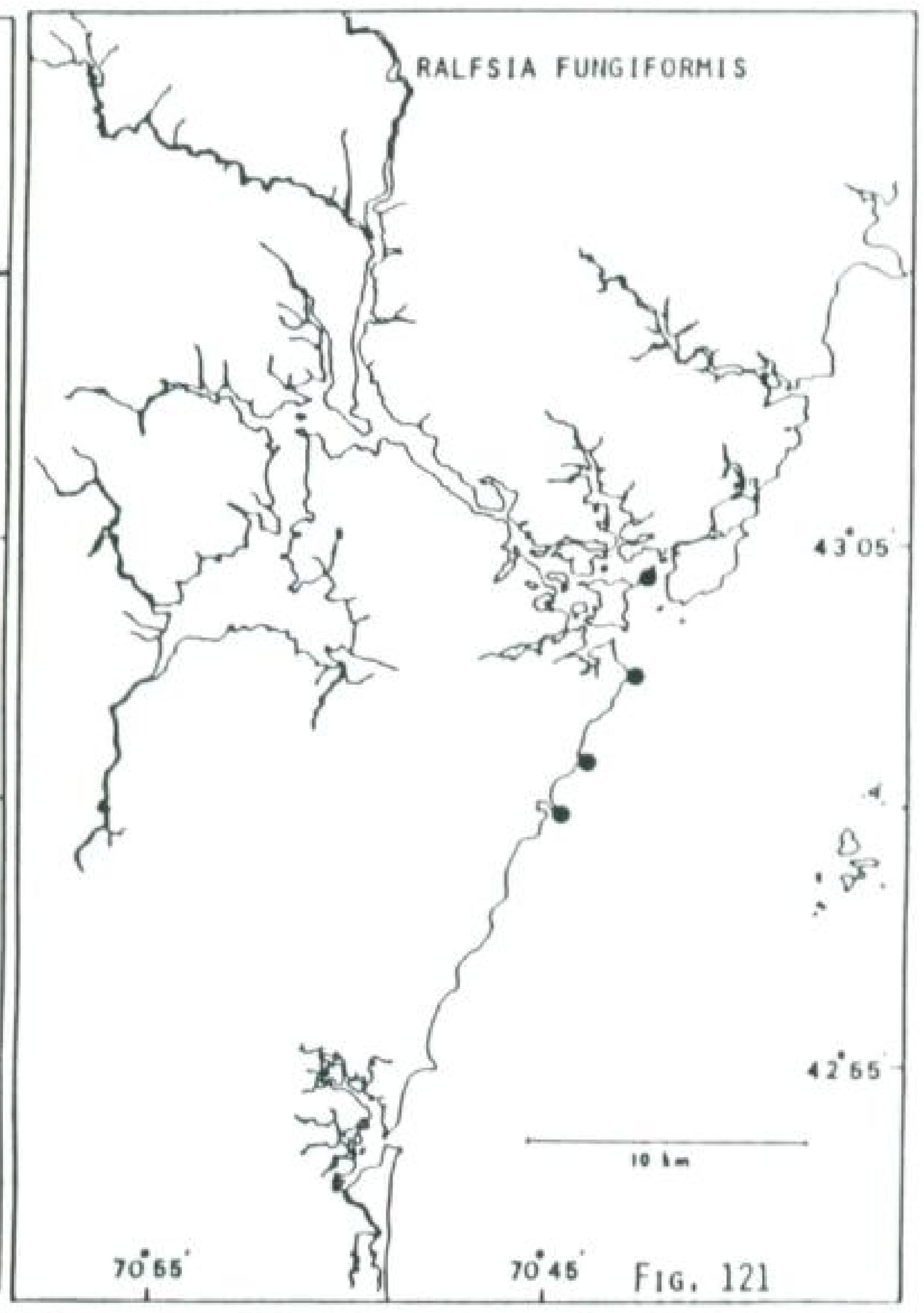


Fig. 121

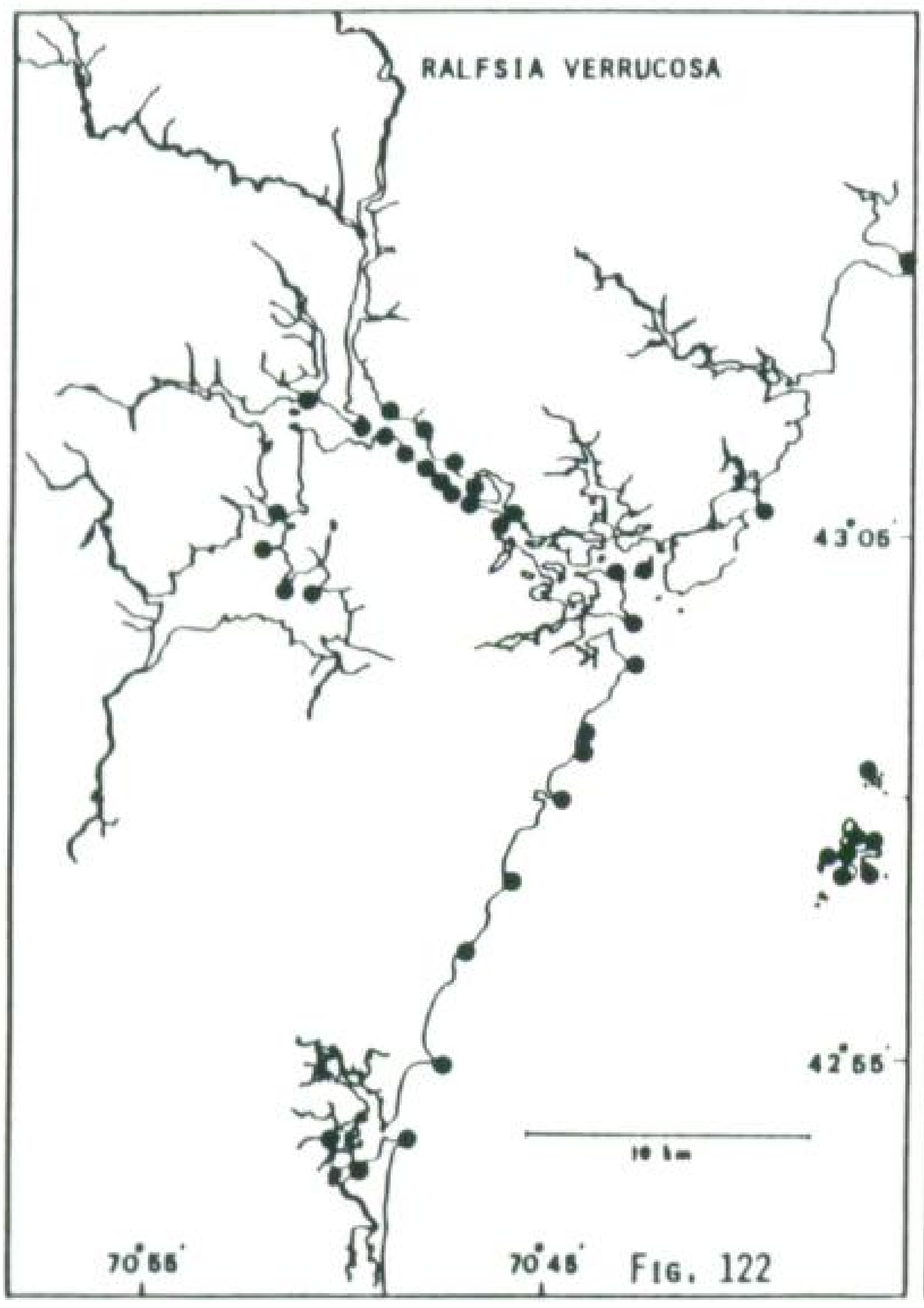


Fig. 122

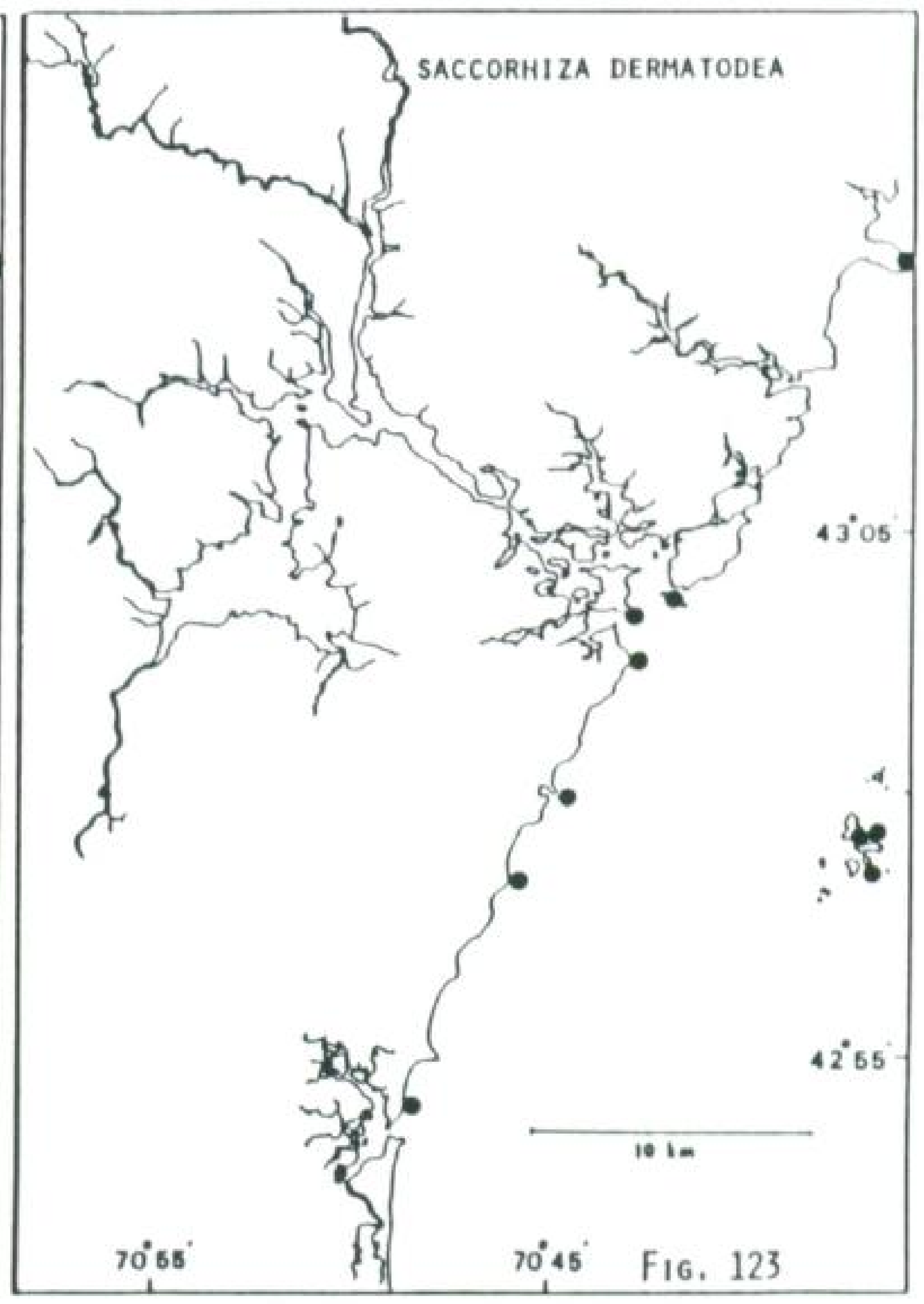


Fig. 123

FIG. 124

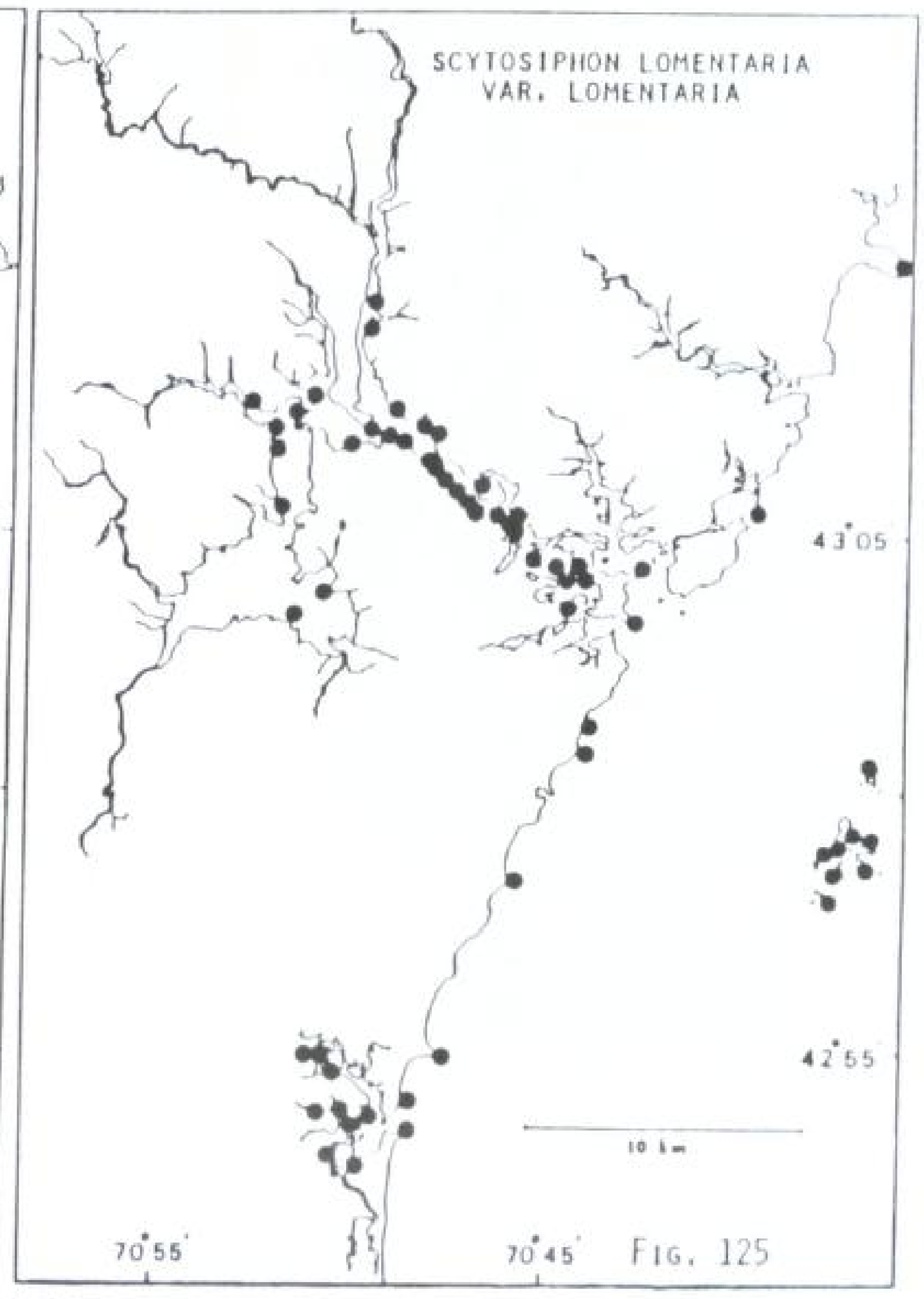


FIG. 125

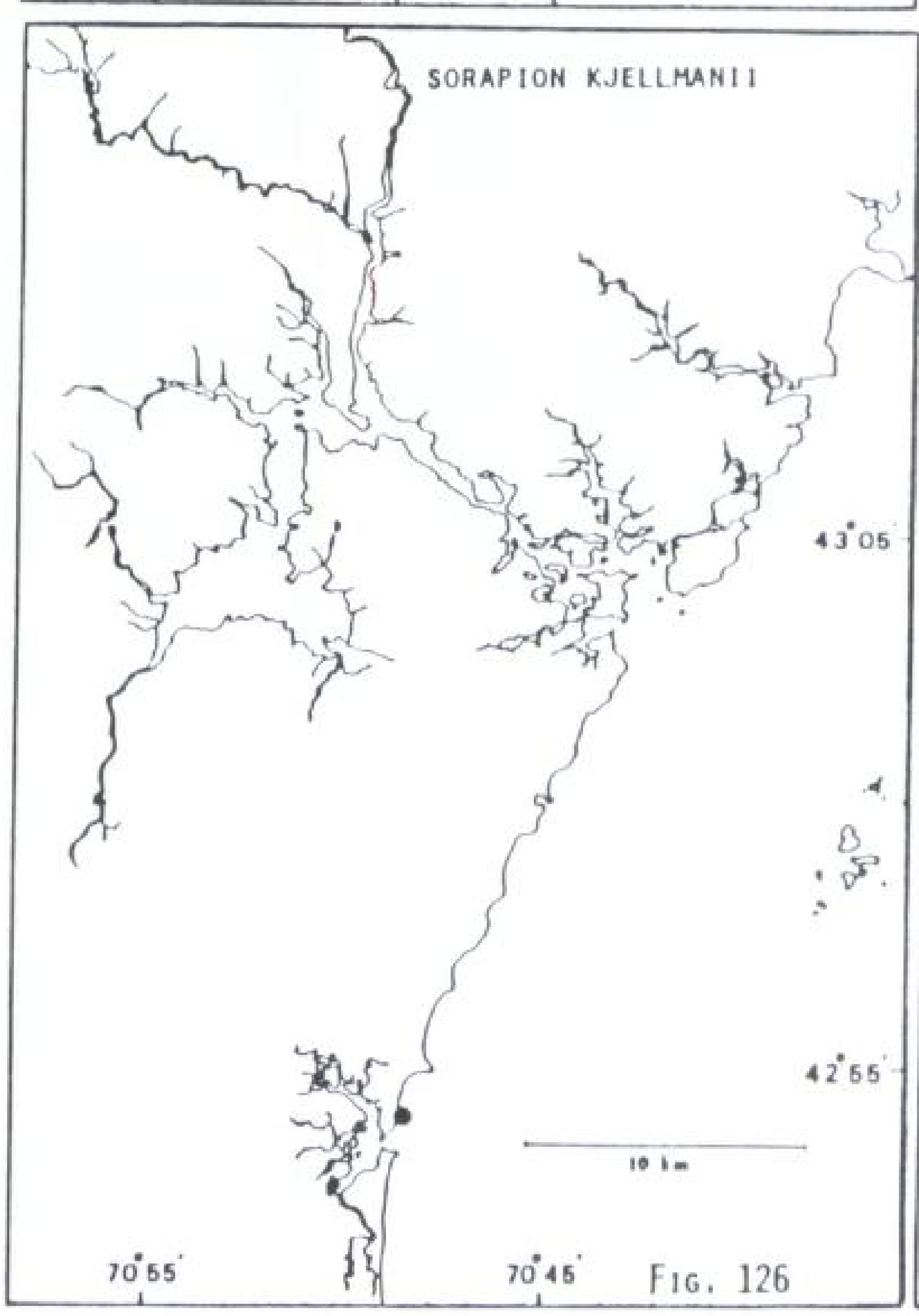


FIG. 126

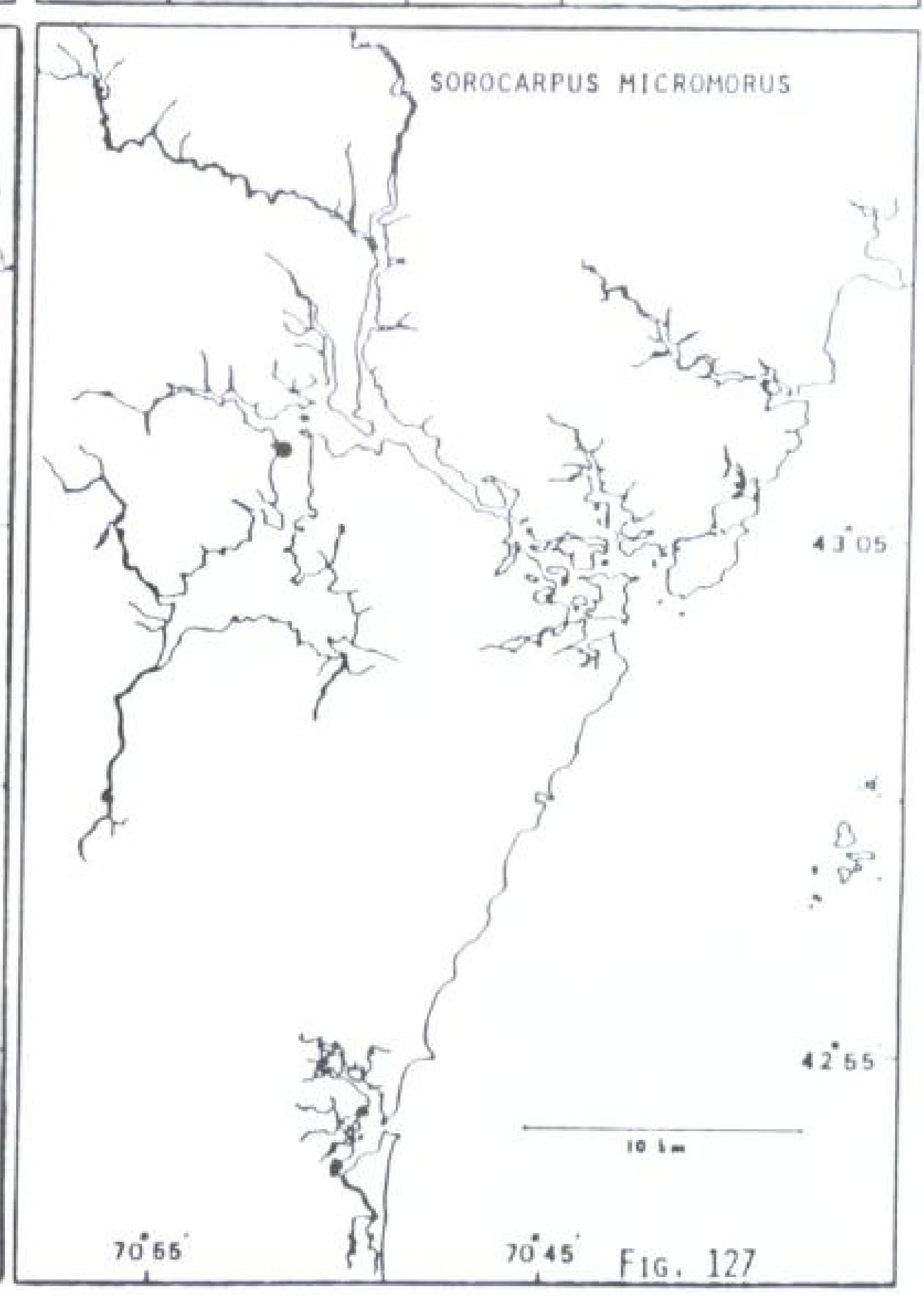


FIG. 127

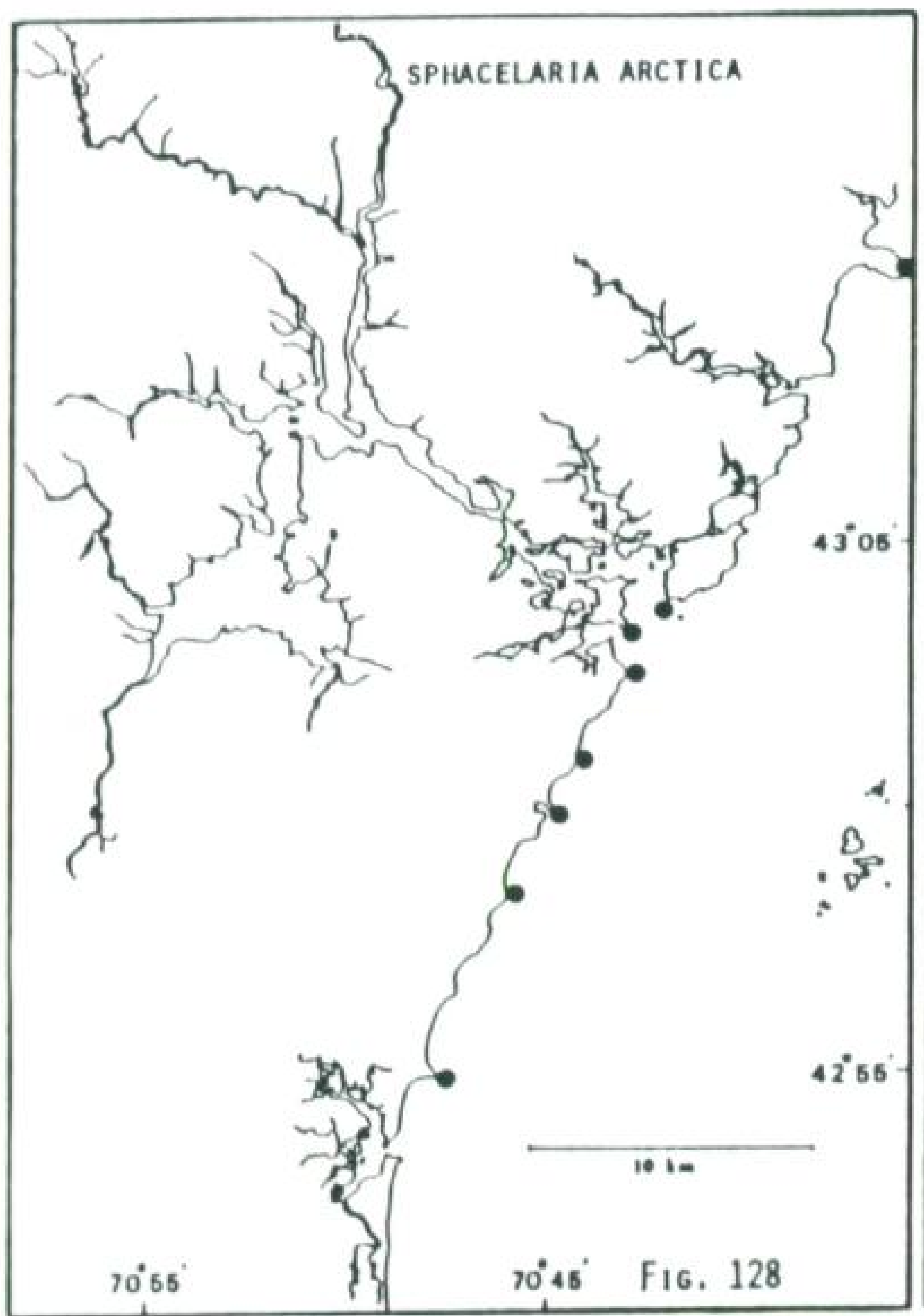
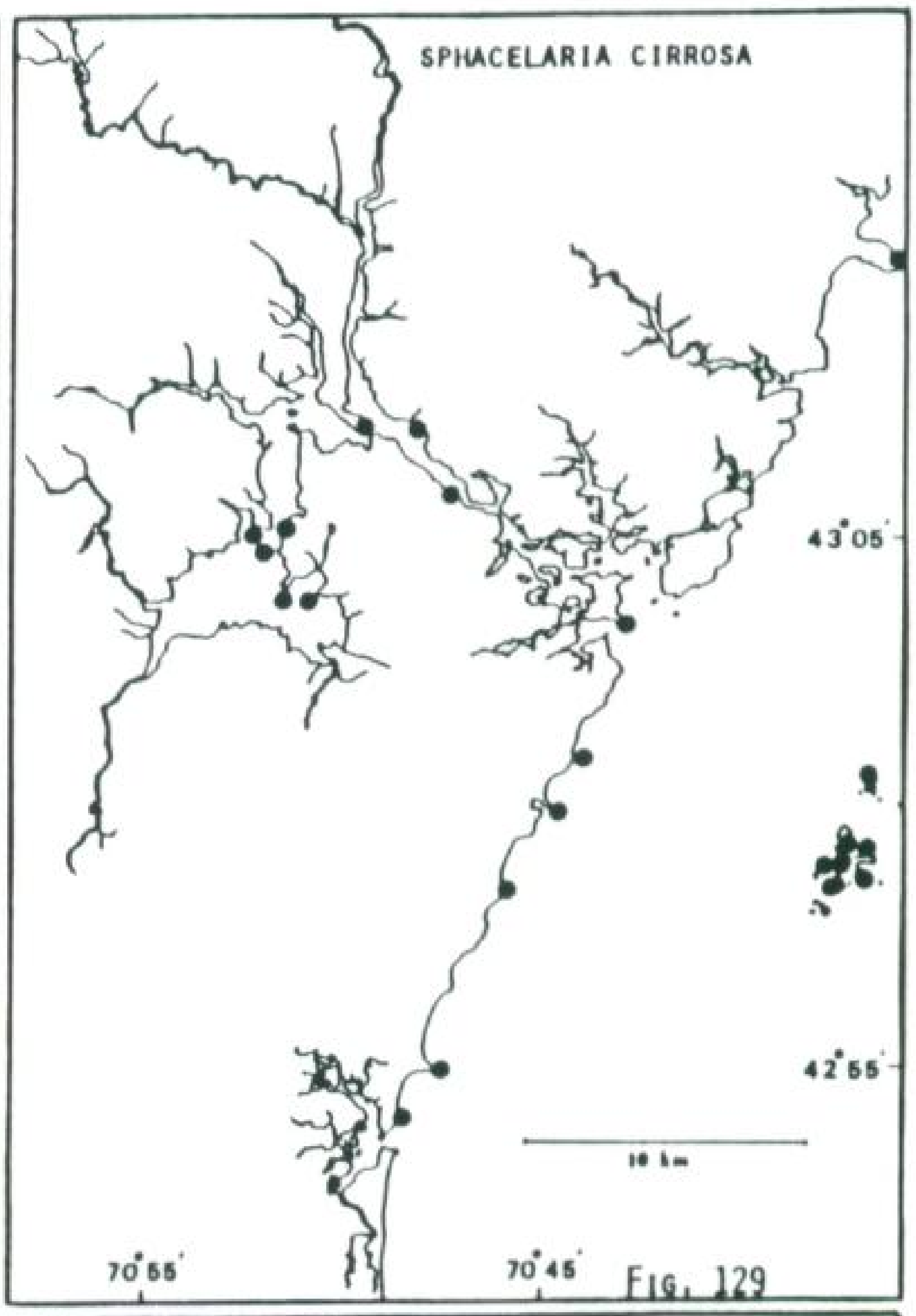


Fig. 128



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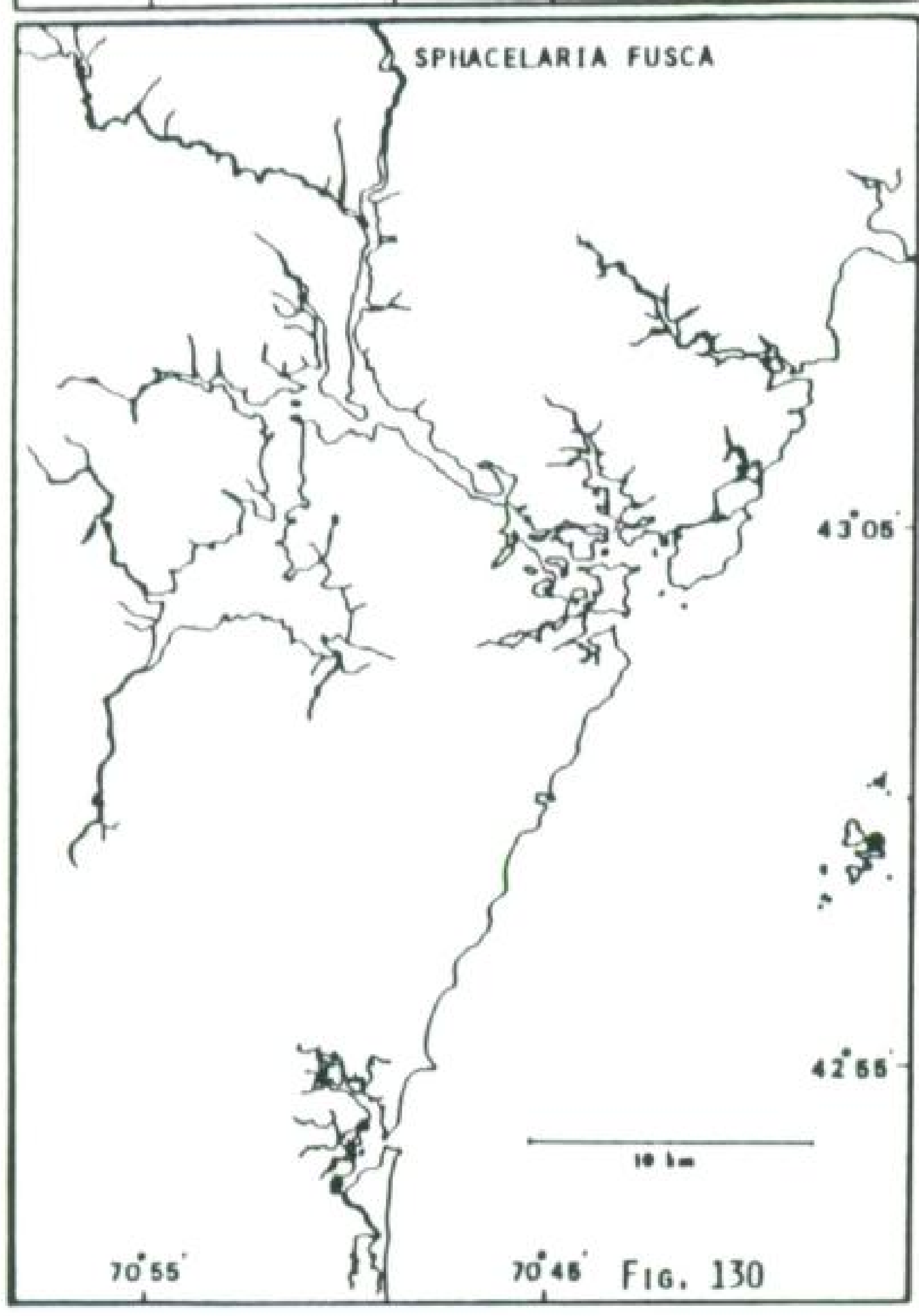


Fig. 130

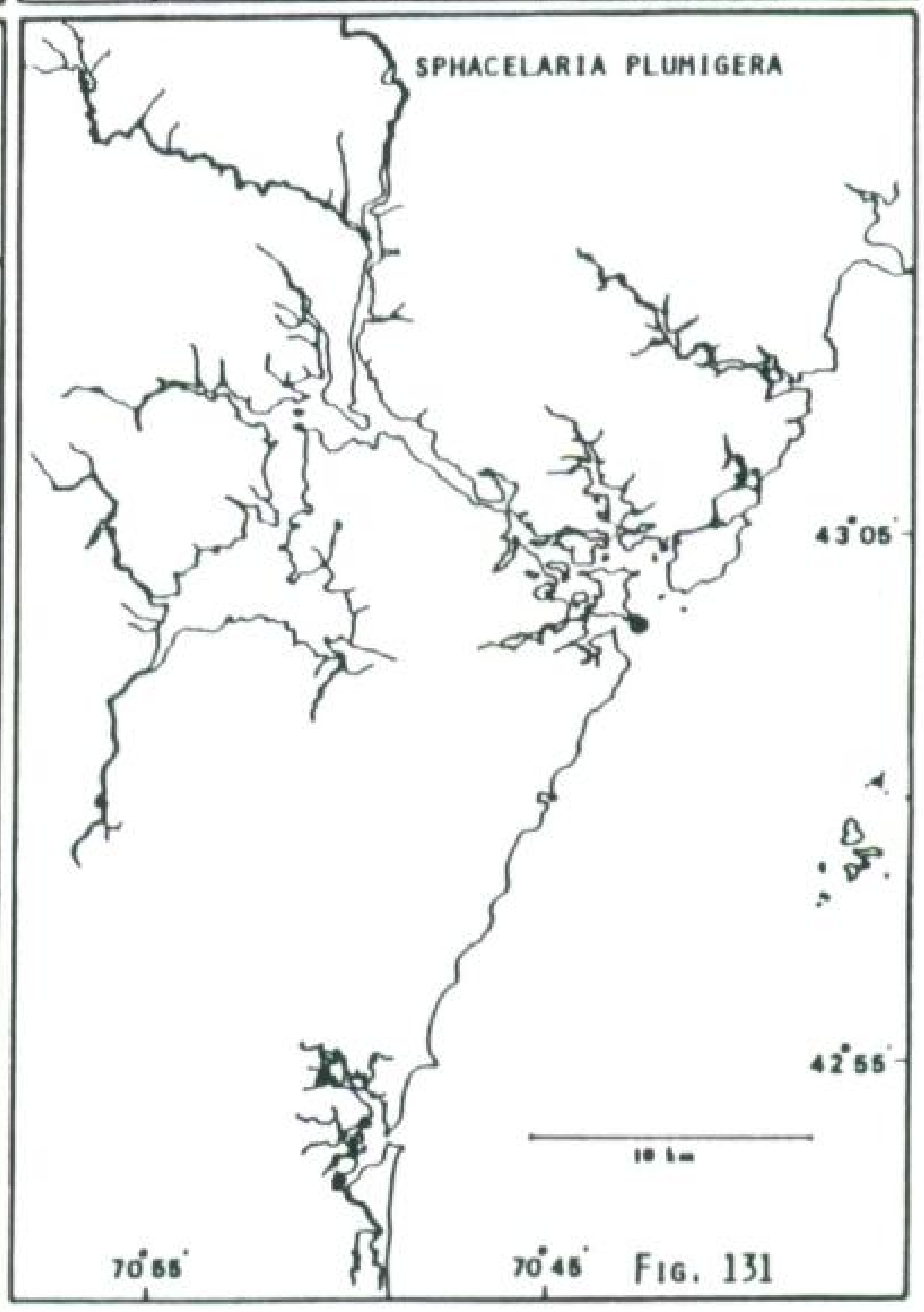


Fig. 131

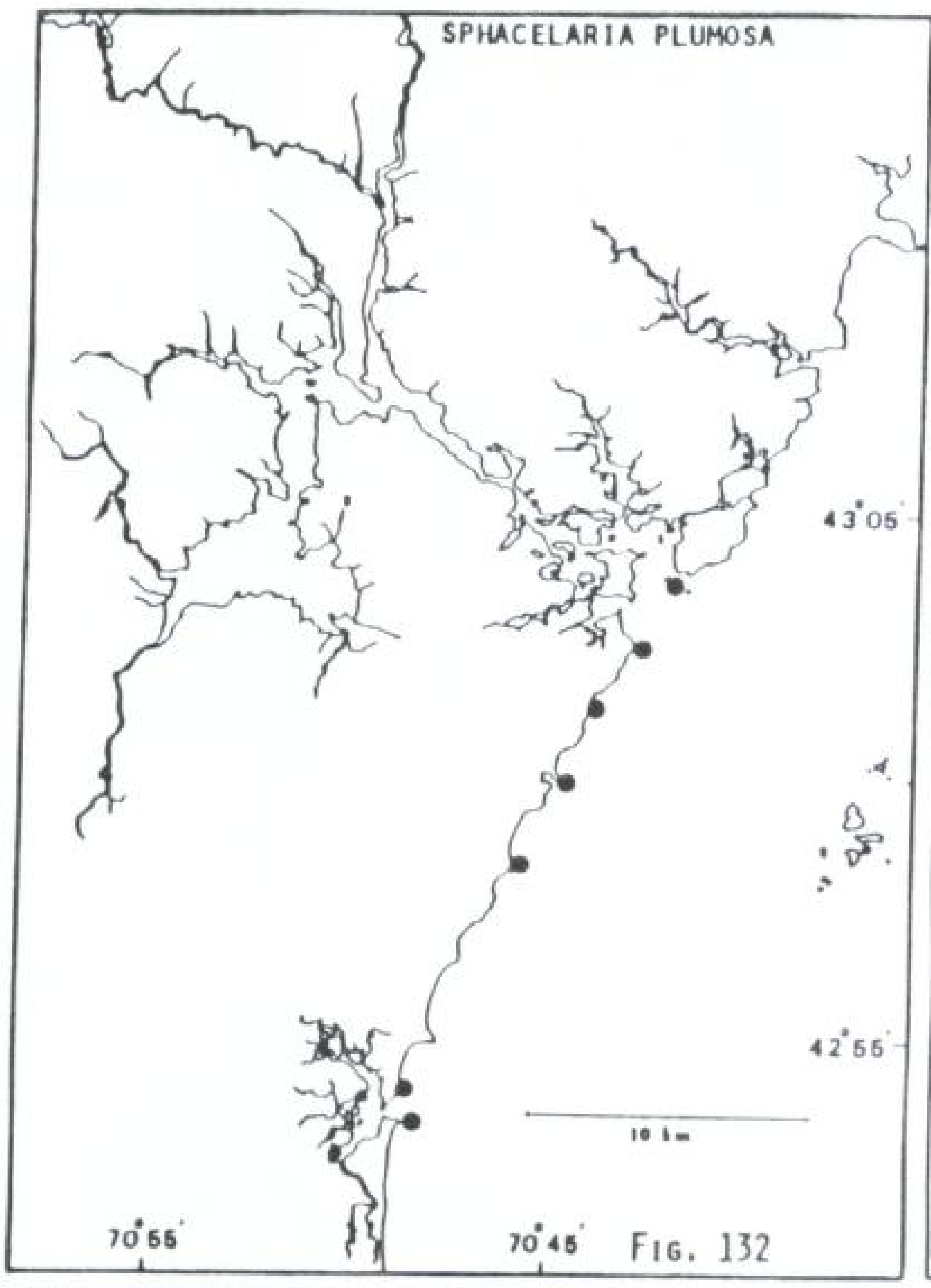


Fig. 132

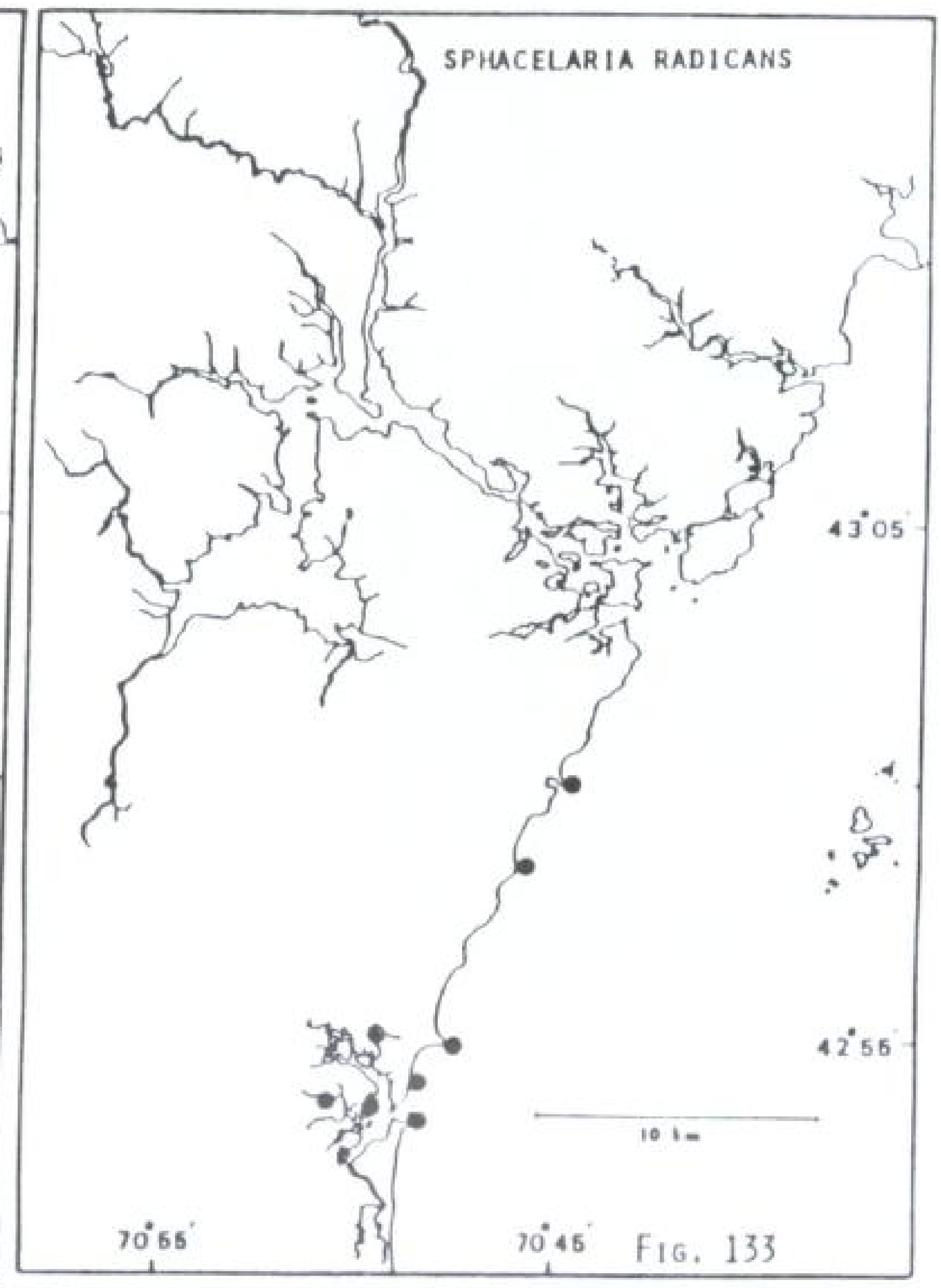


Fig. 133

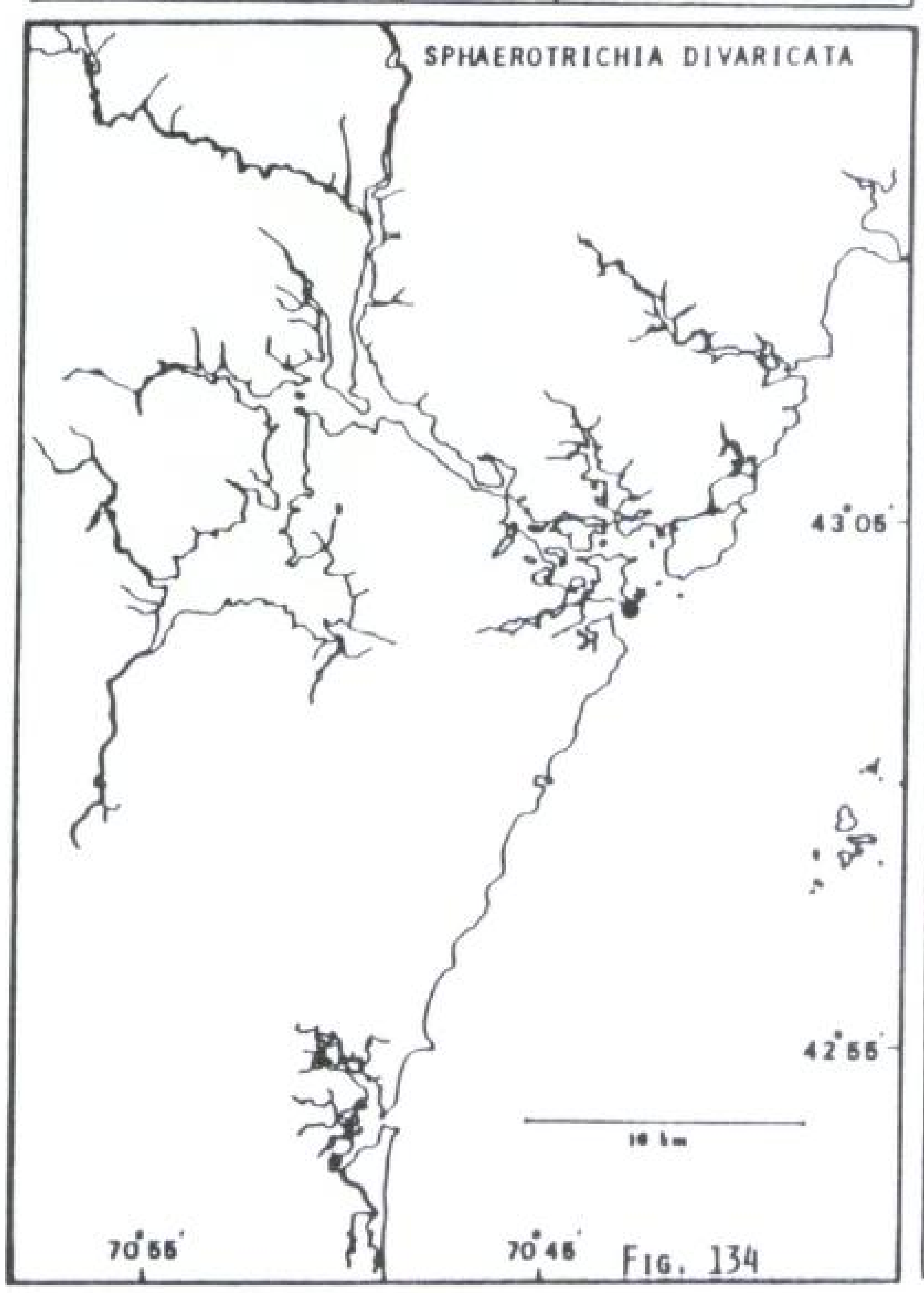


Fig. 134

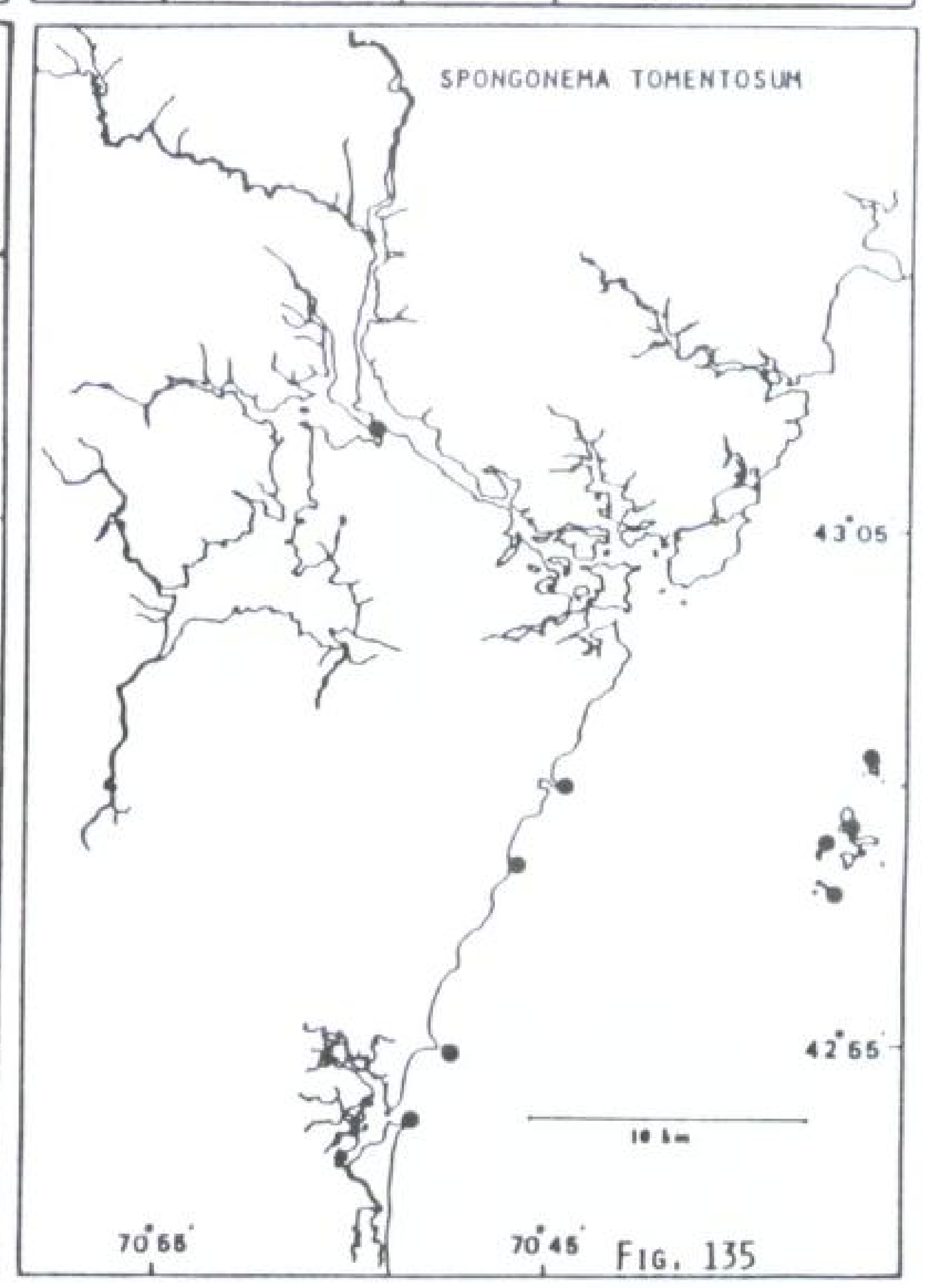


Fig. 135

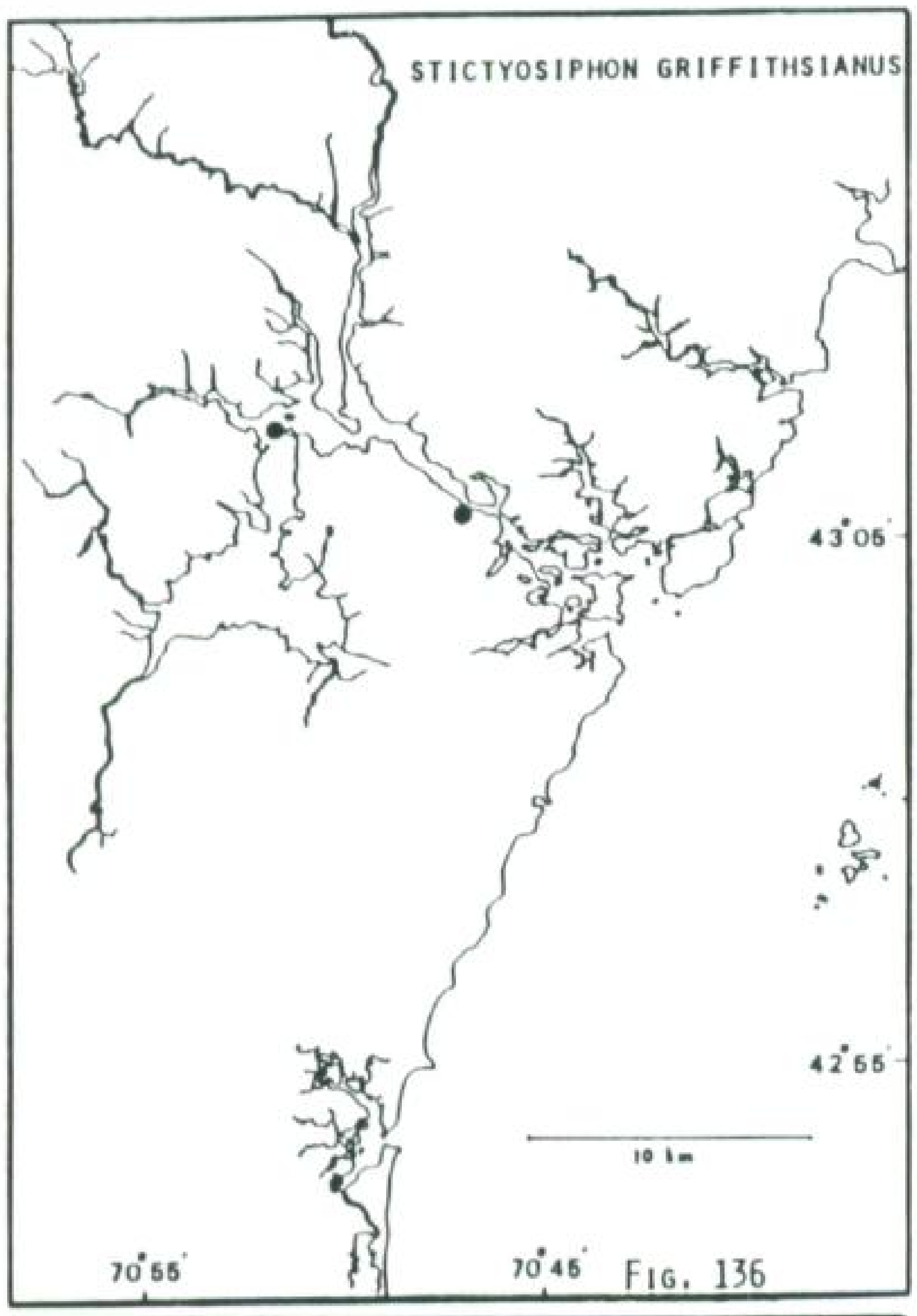


FIG. 136

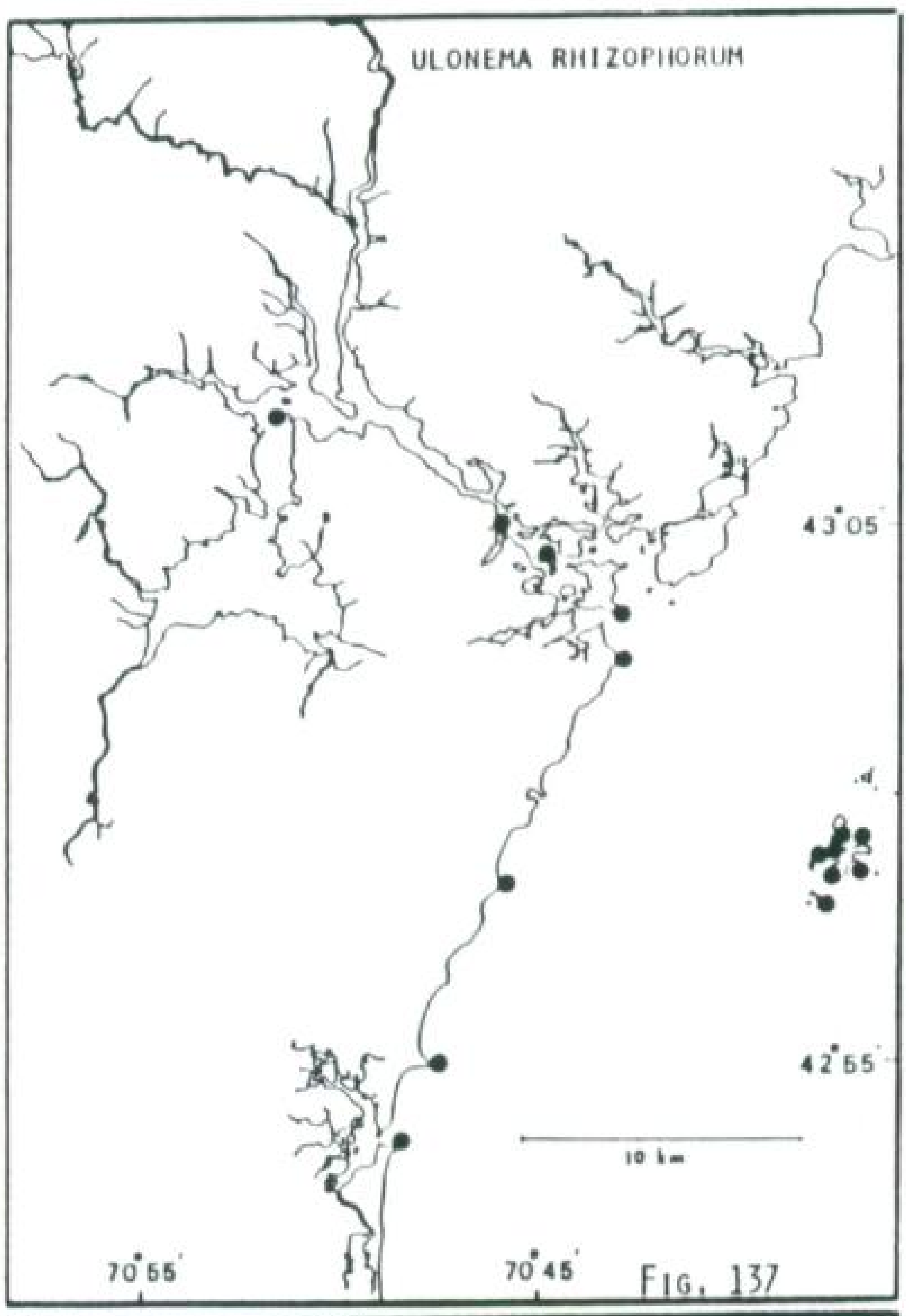


FIG. 137

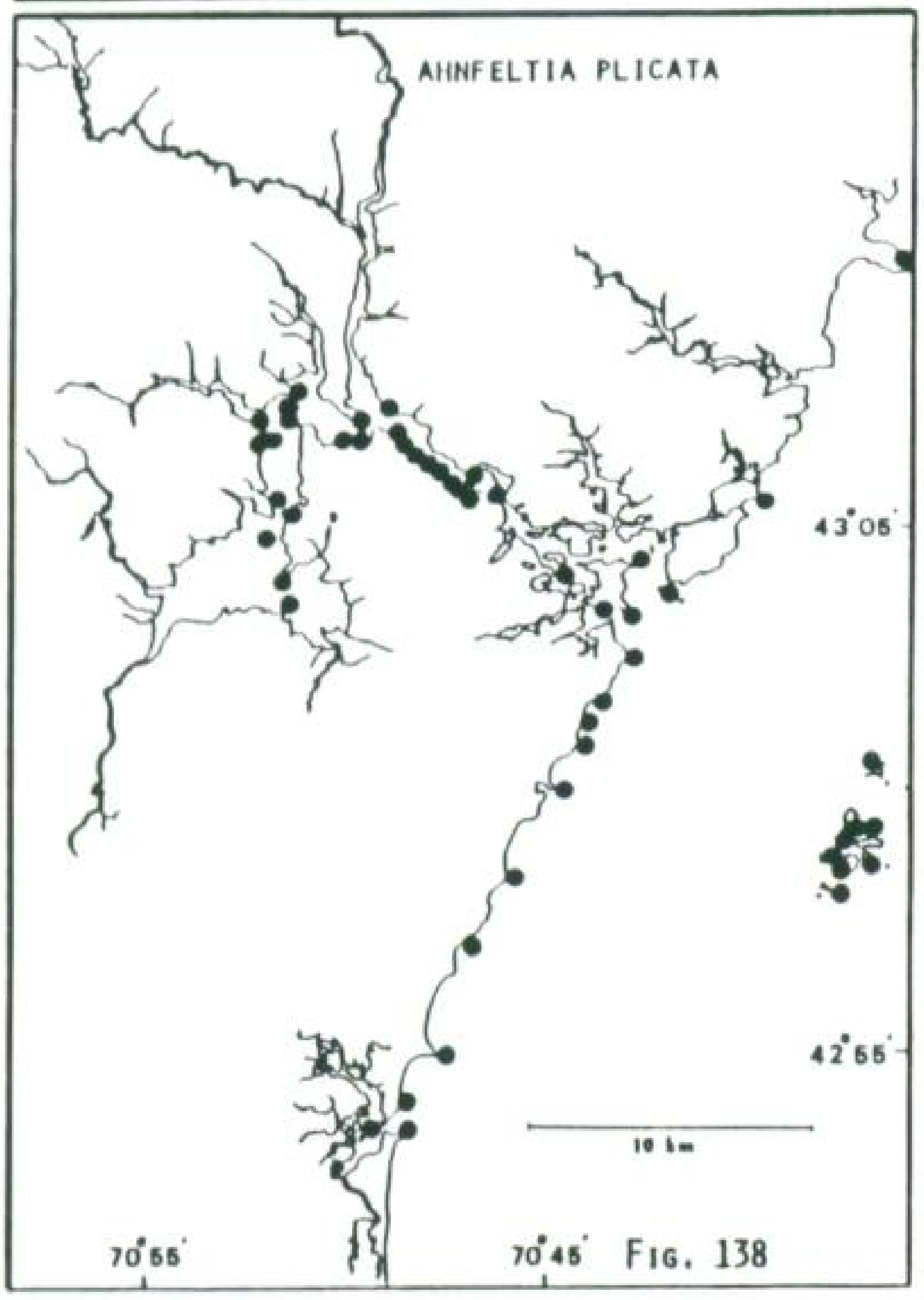


FIG. 138

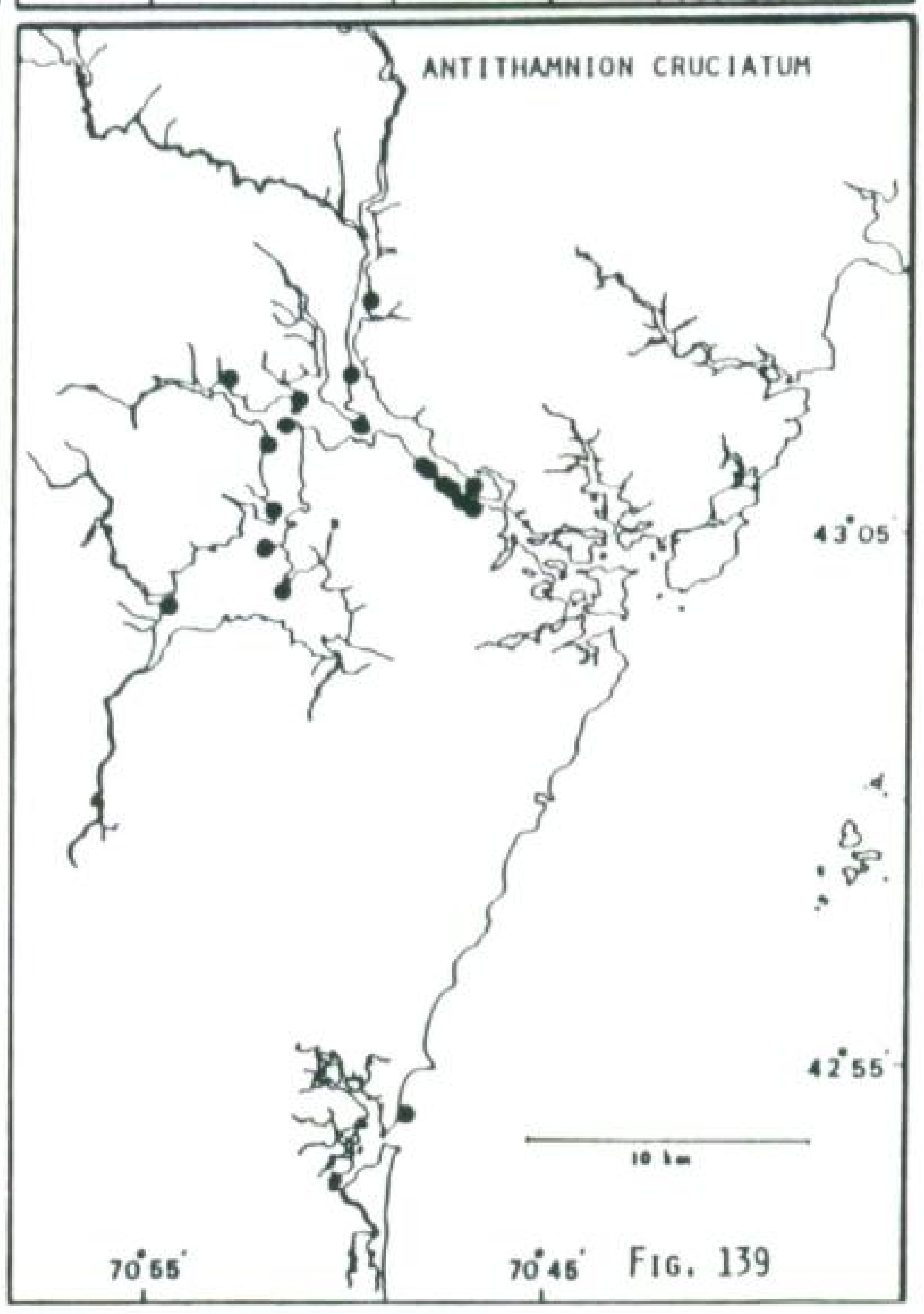


FIG. 139

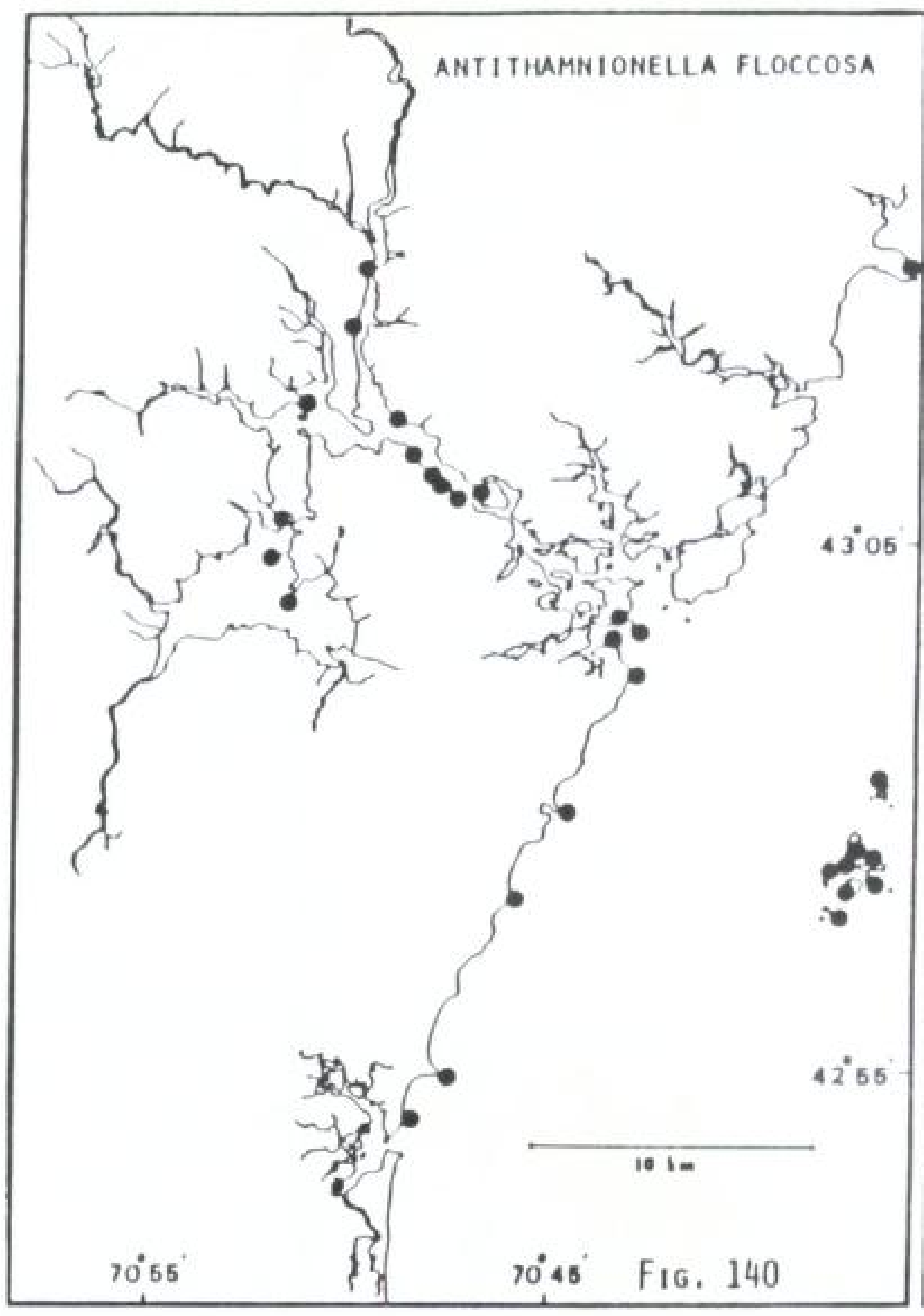


Fig. 140

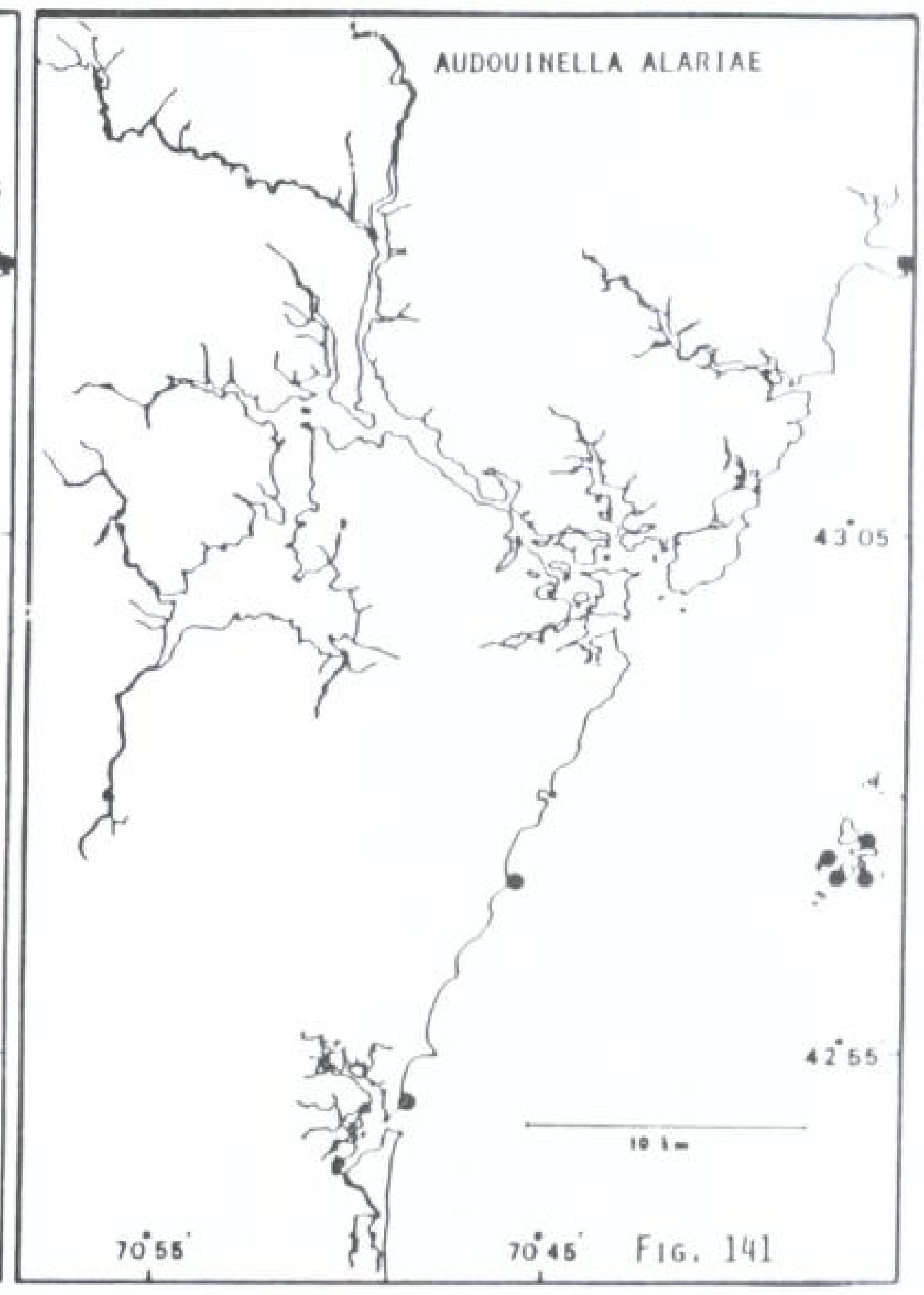


Fig. 141

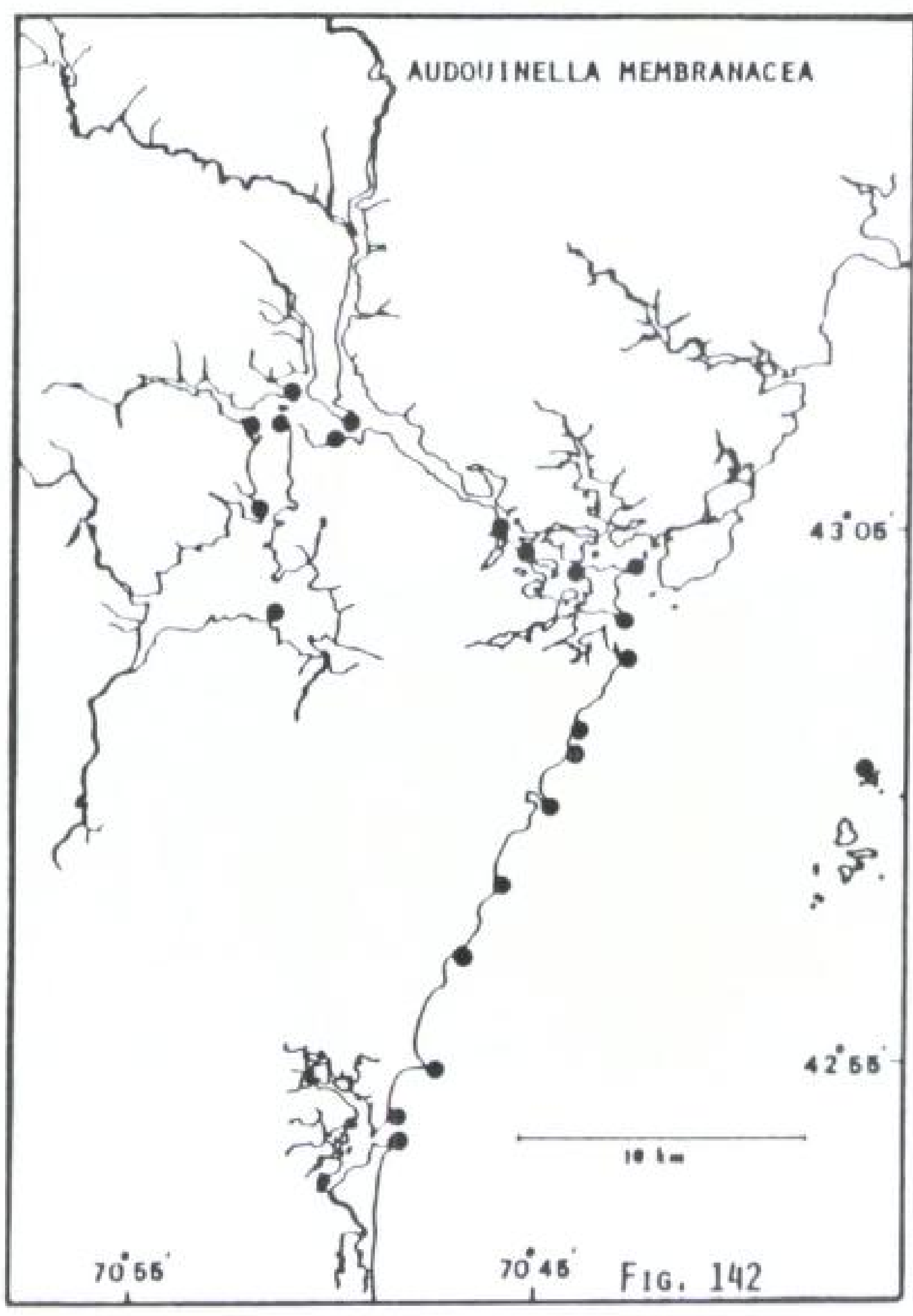


Fig. 142

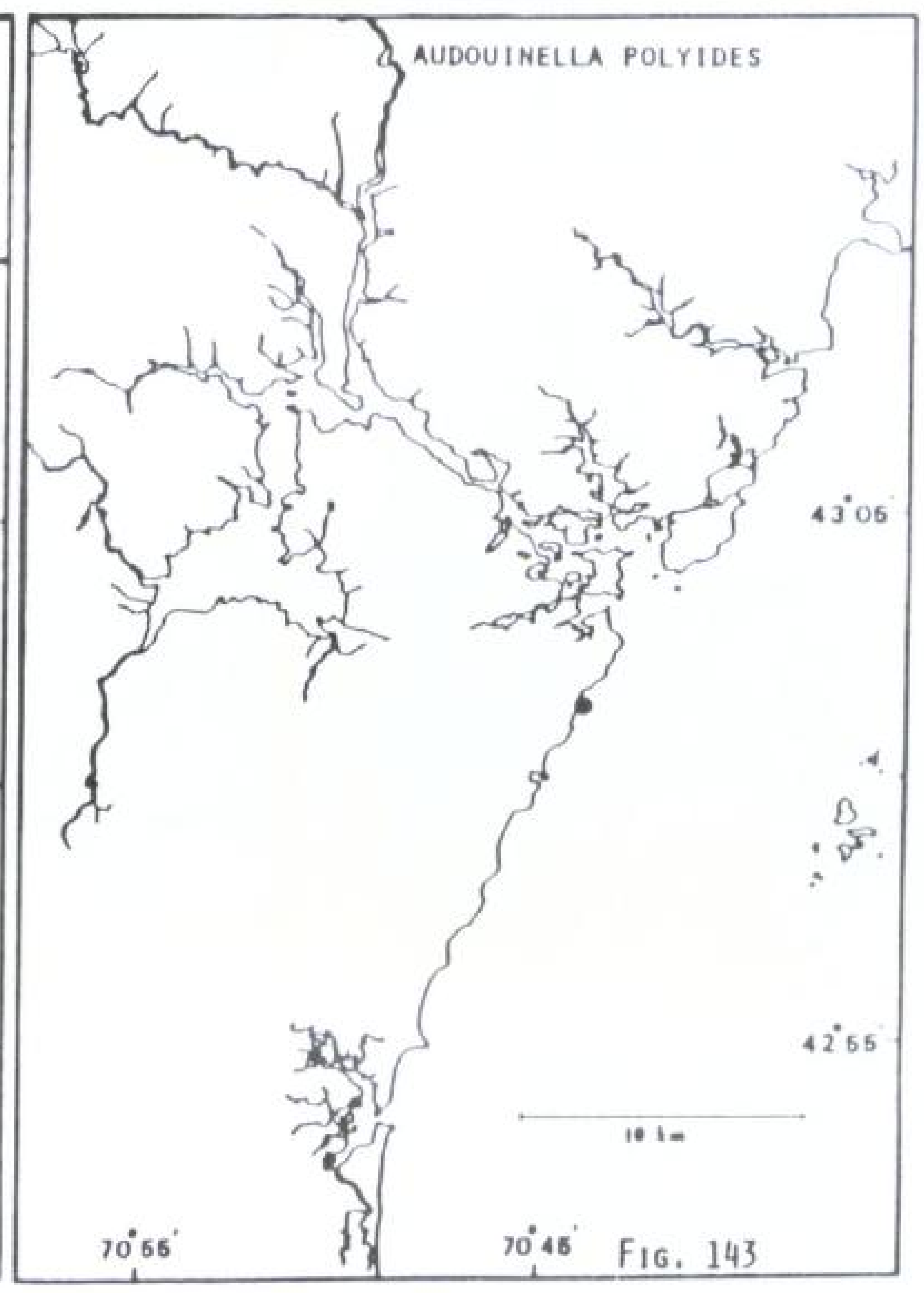


Fig. 143

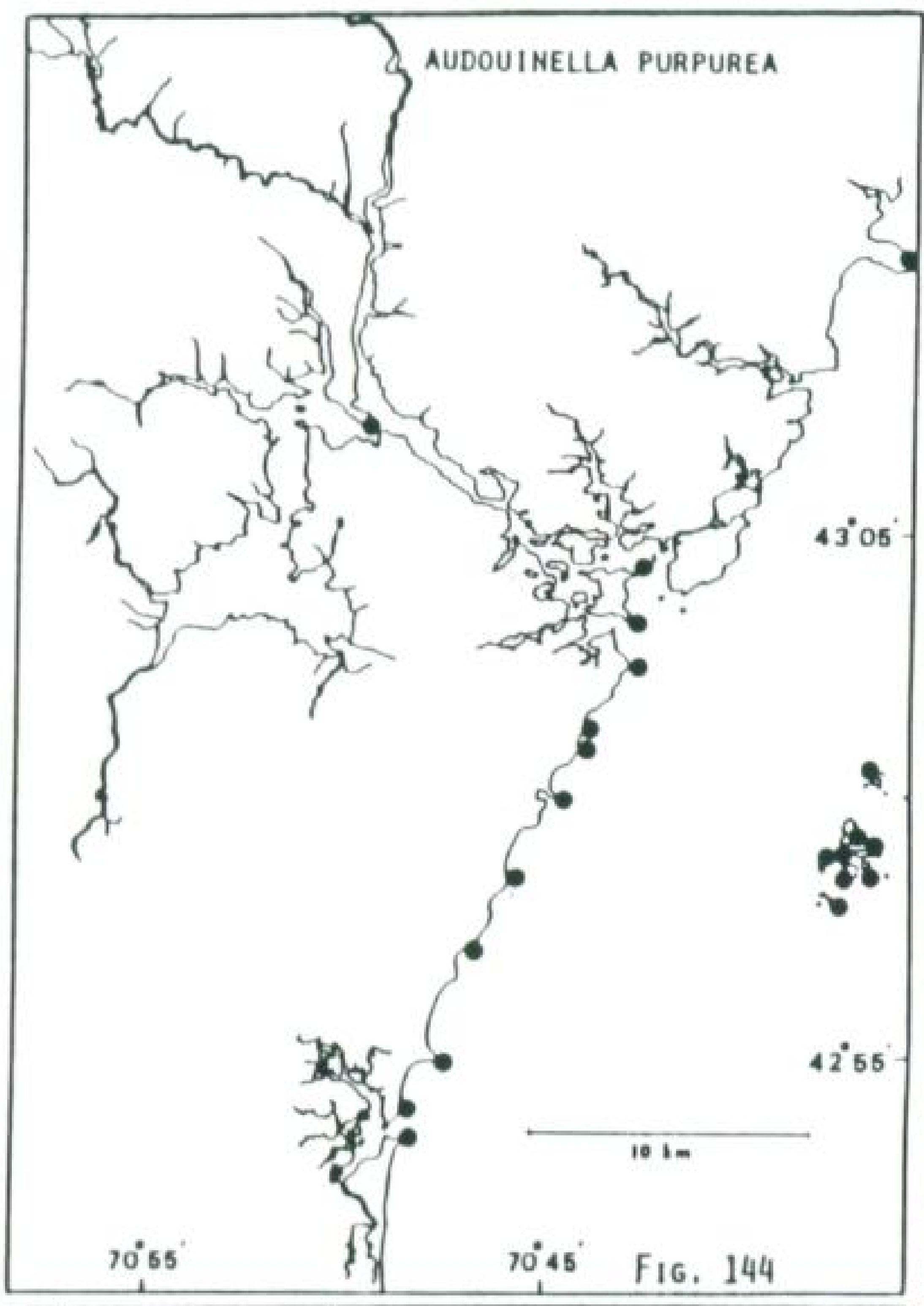


Fig. 144

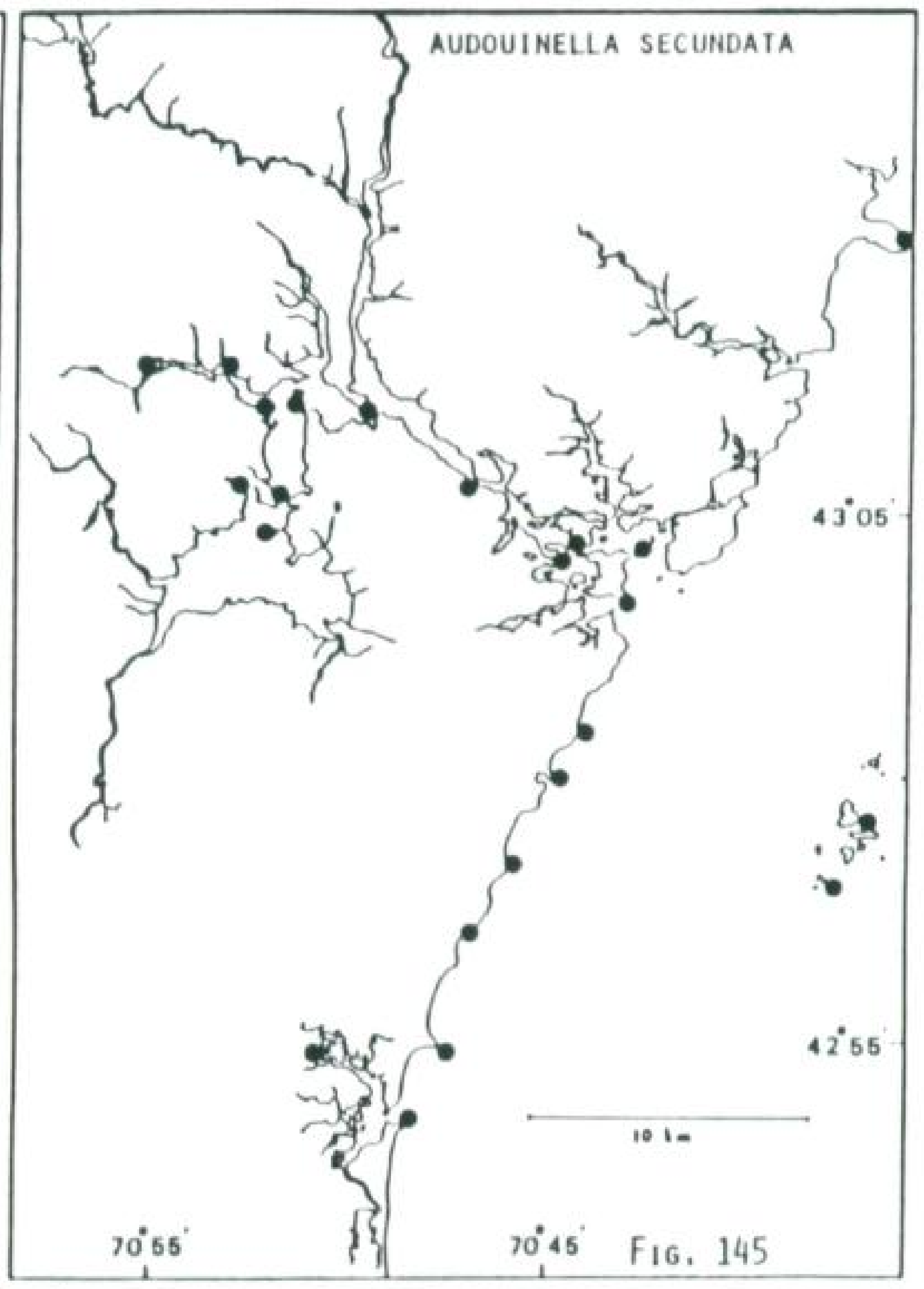


Fig. 145

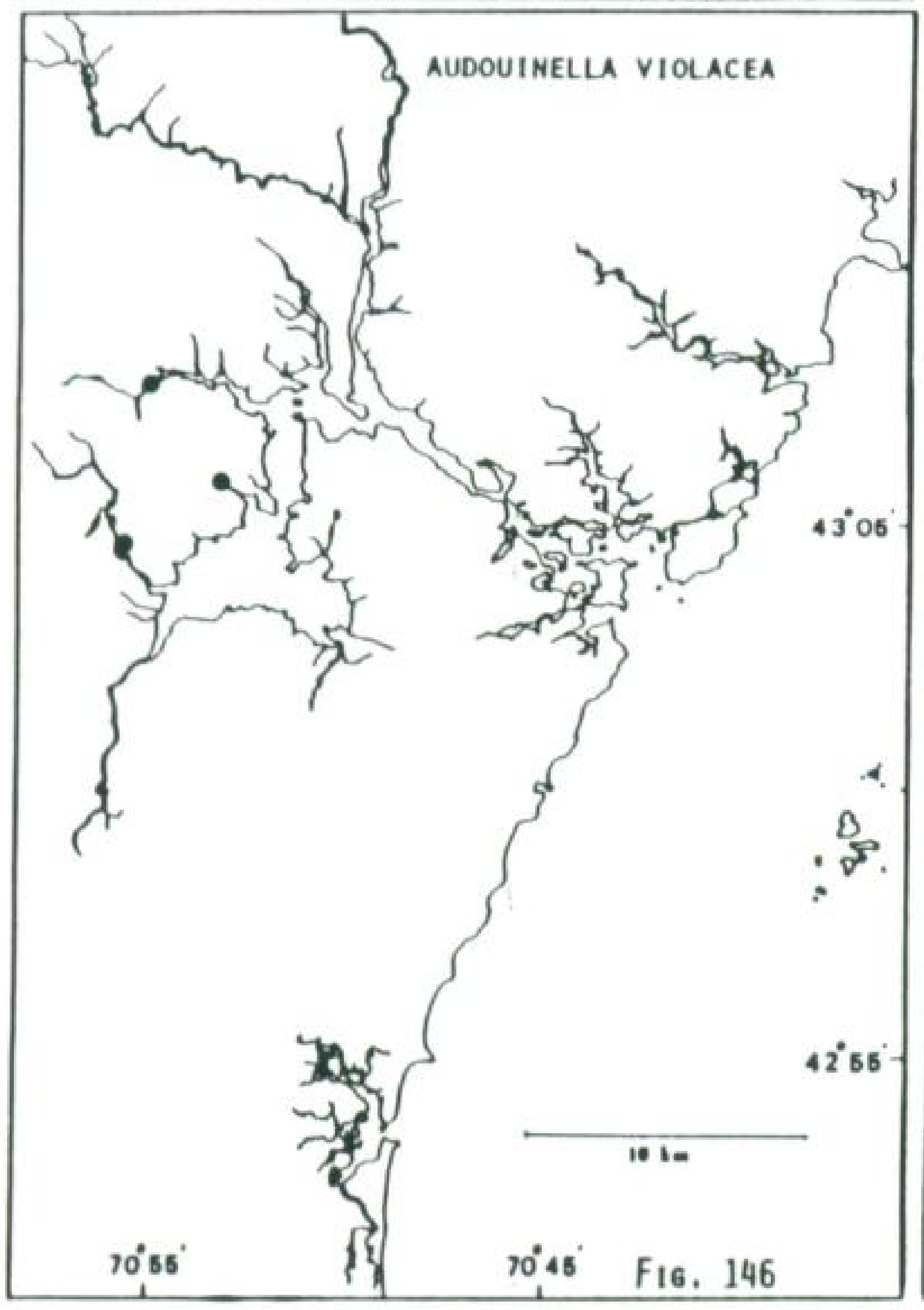


Fig. 146

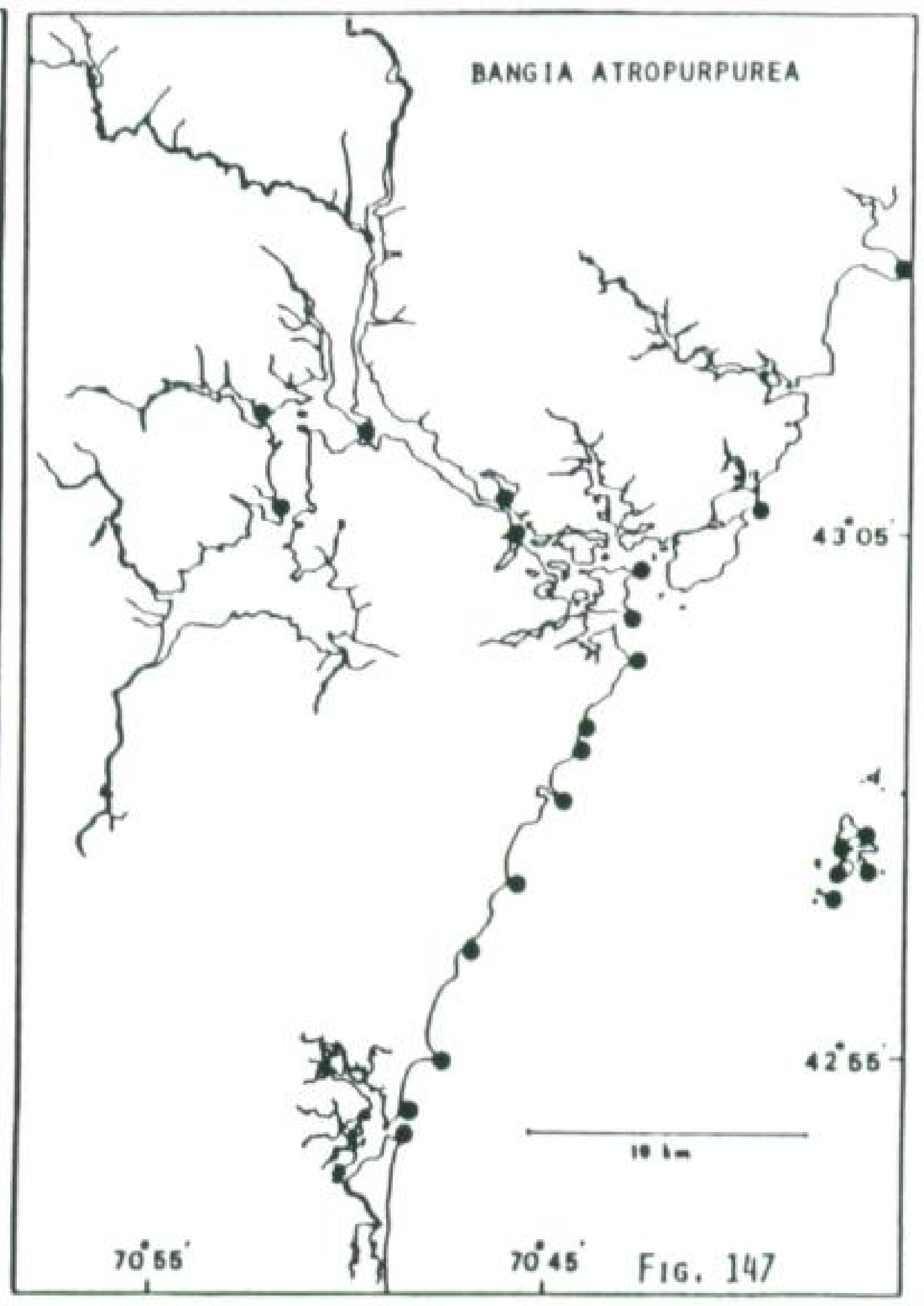


Fig. 147

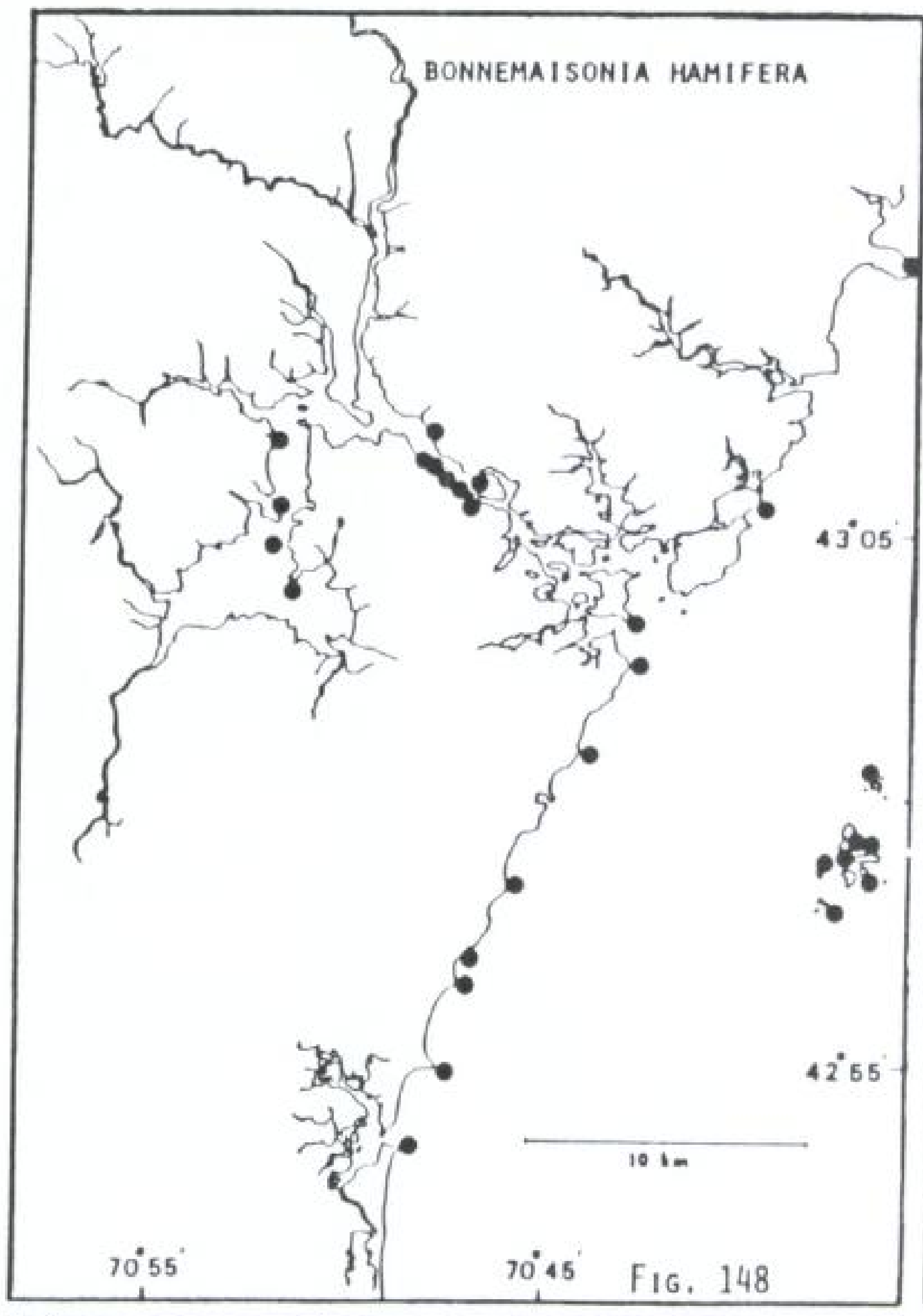
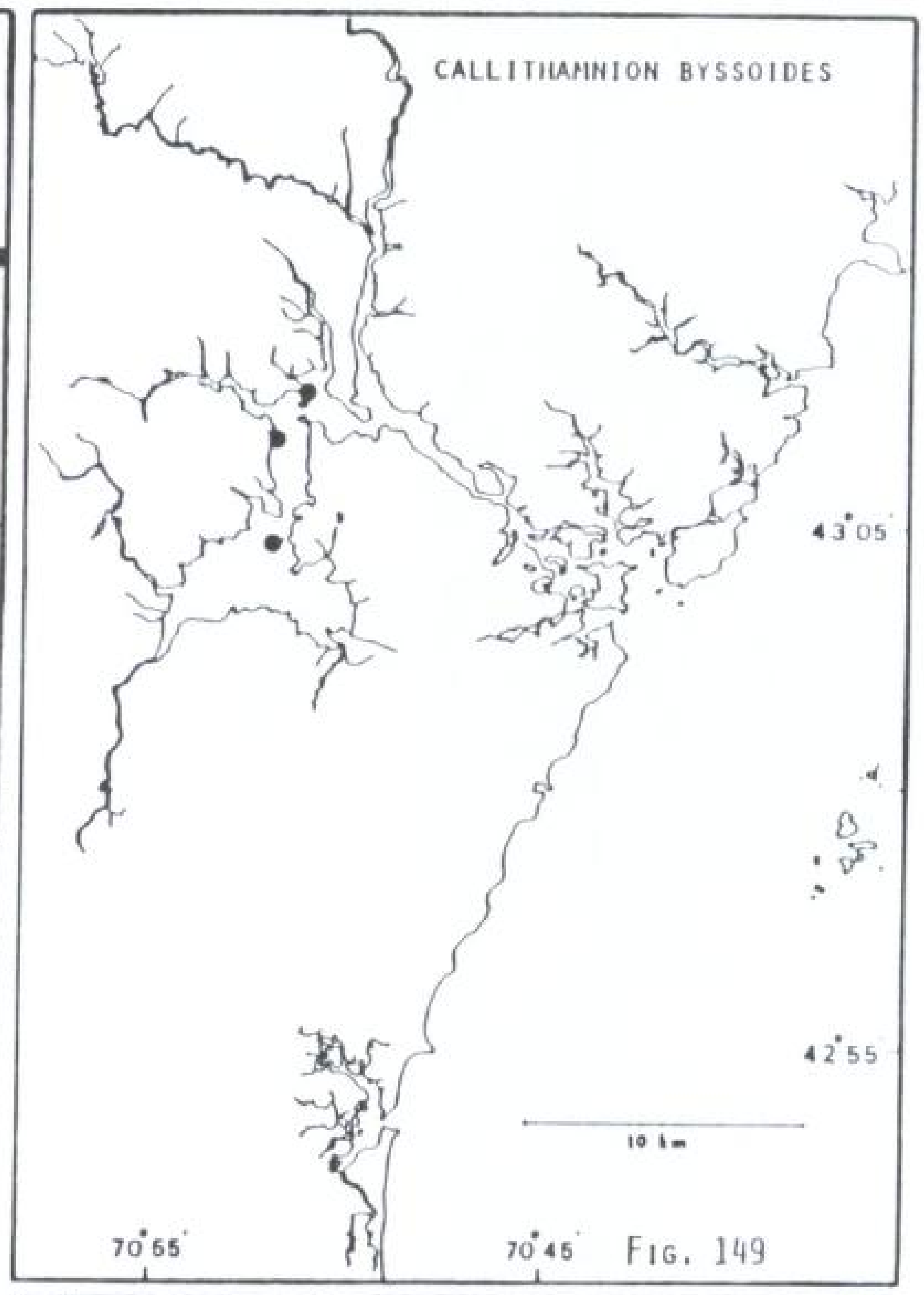


Fig. 148



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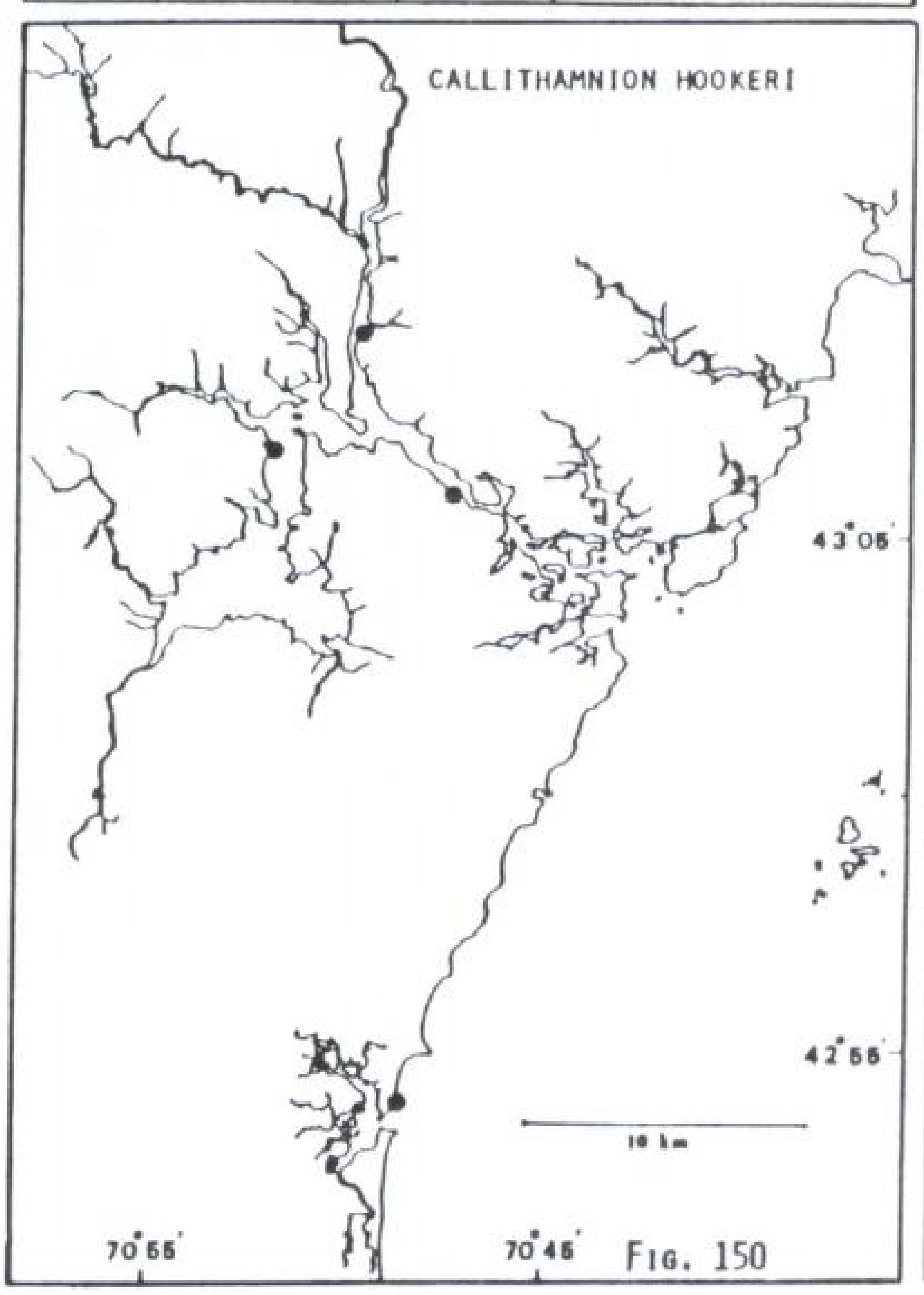


Fig. 150

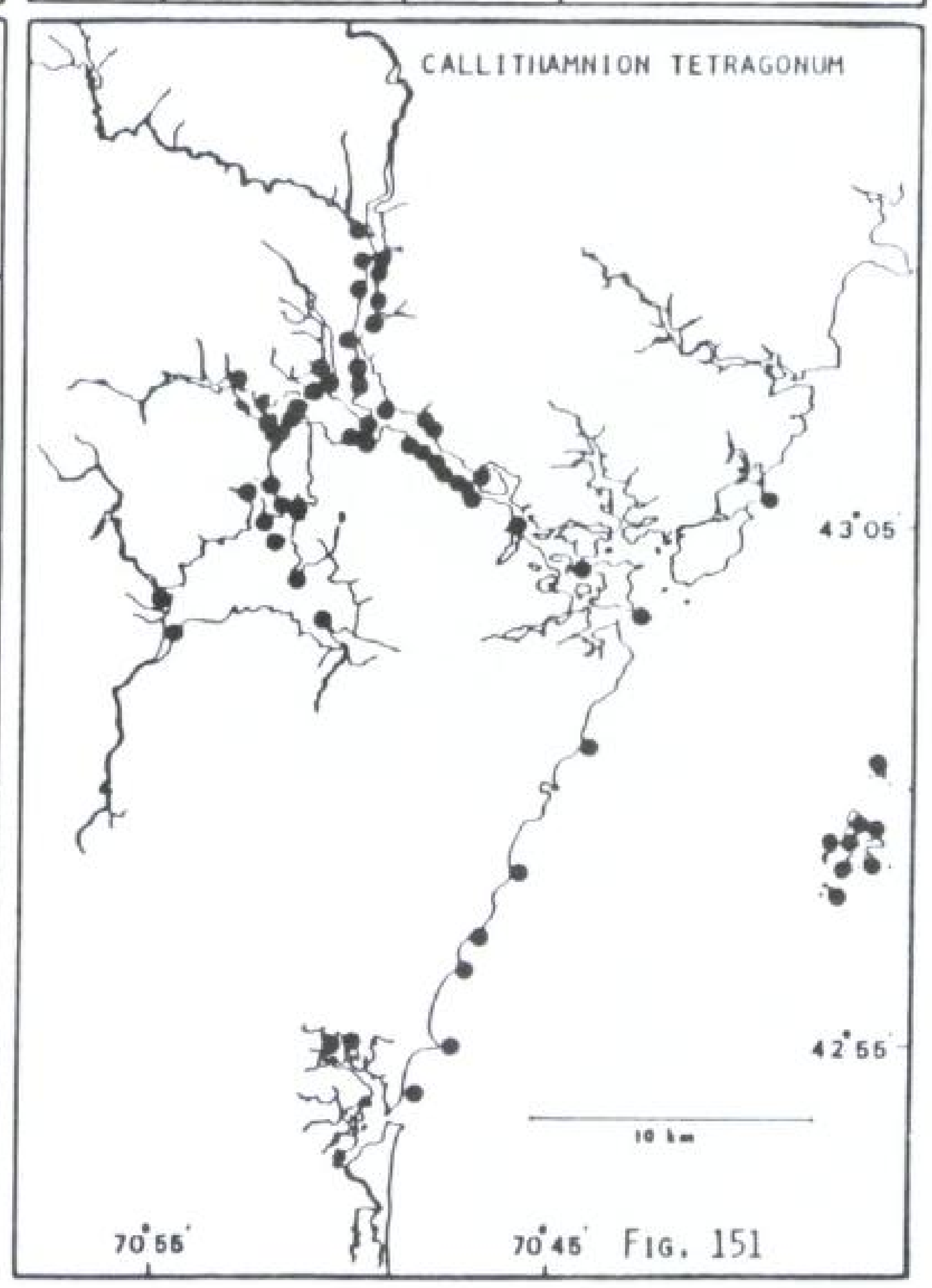
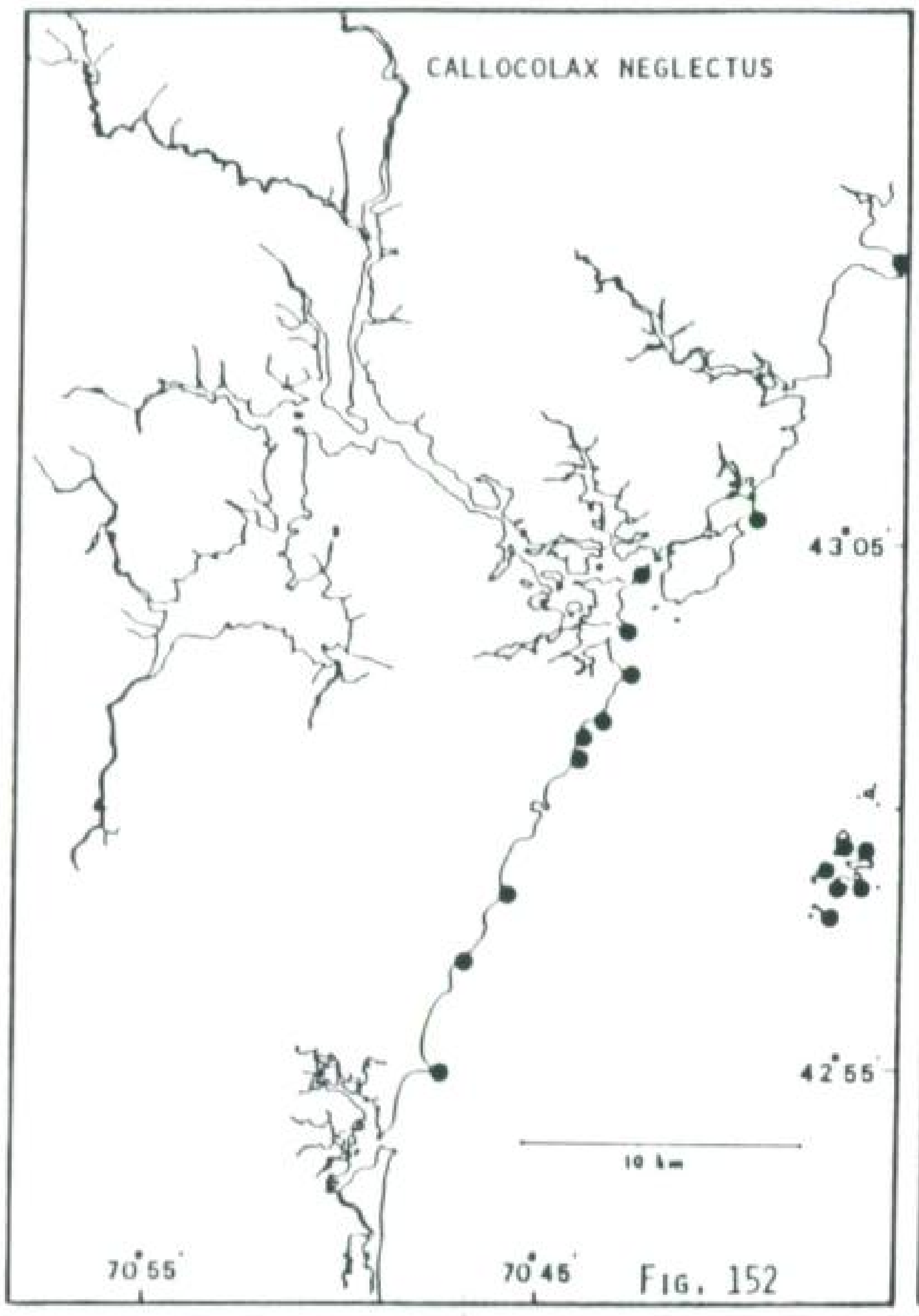
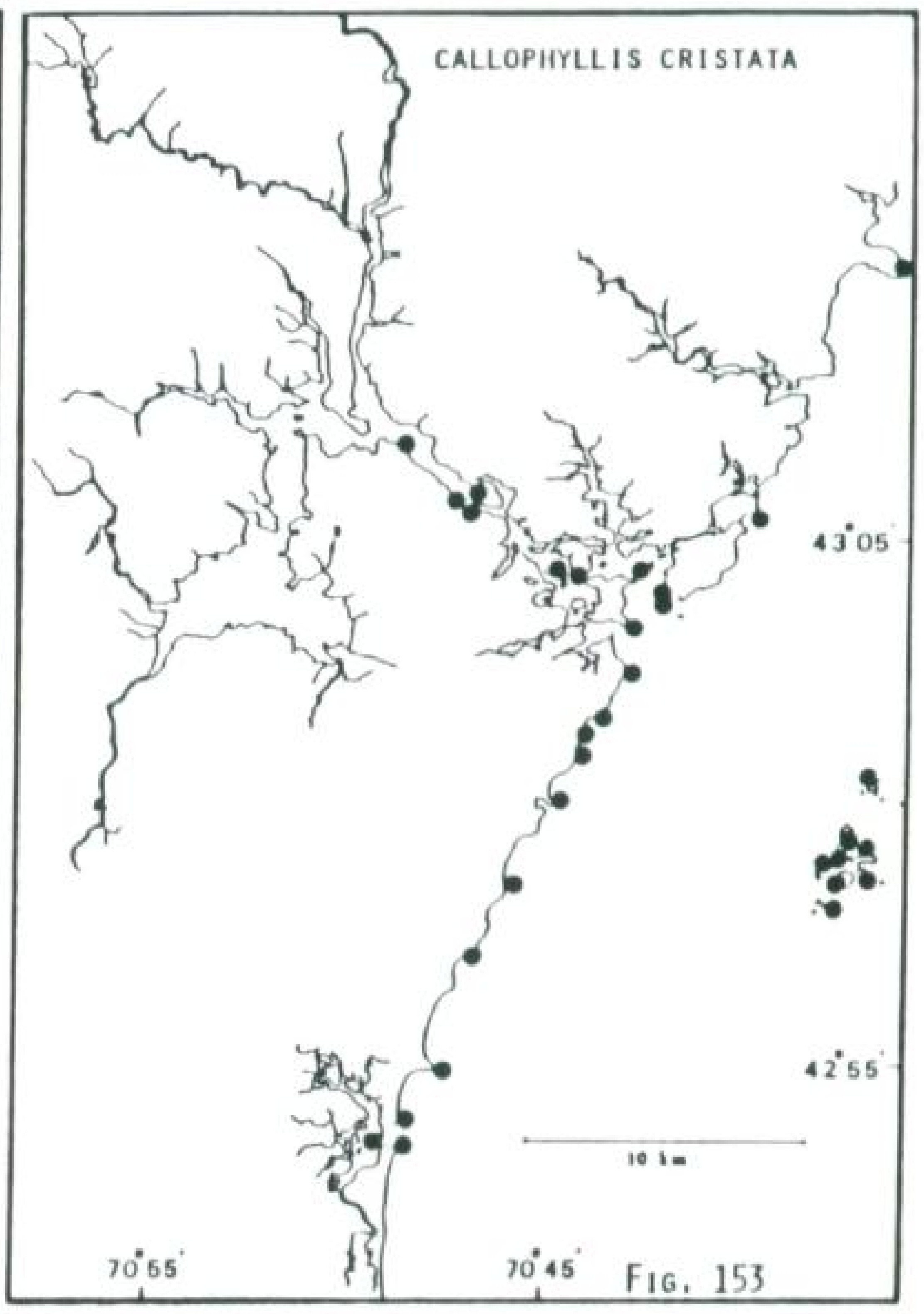
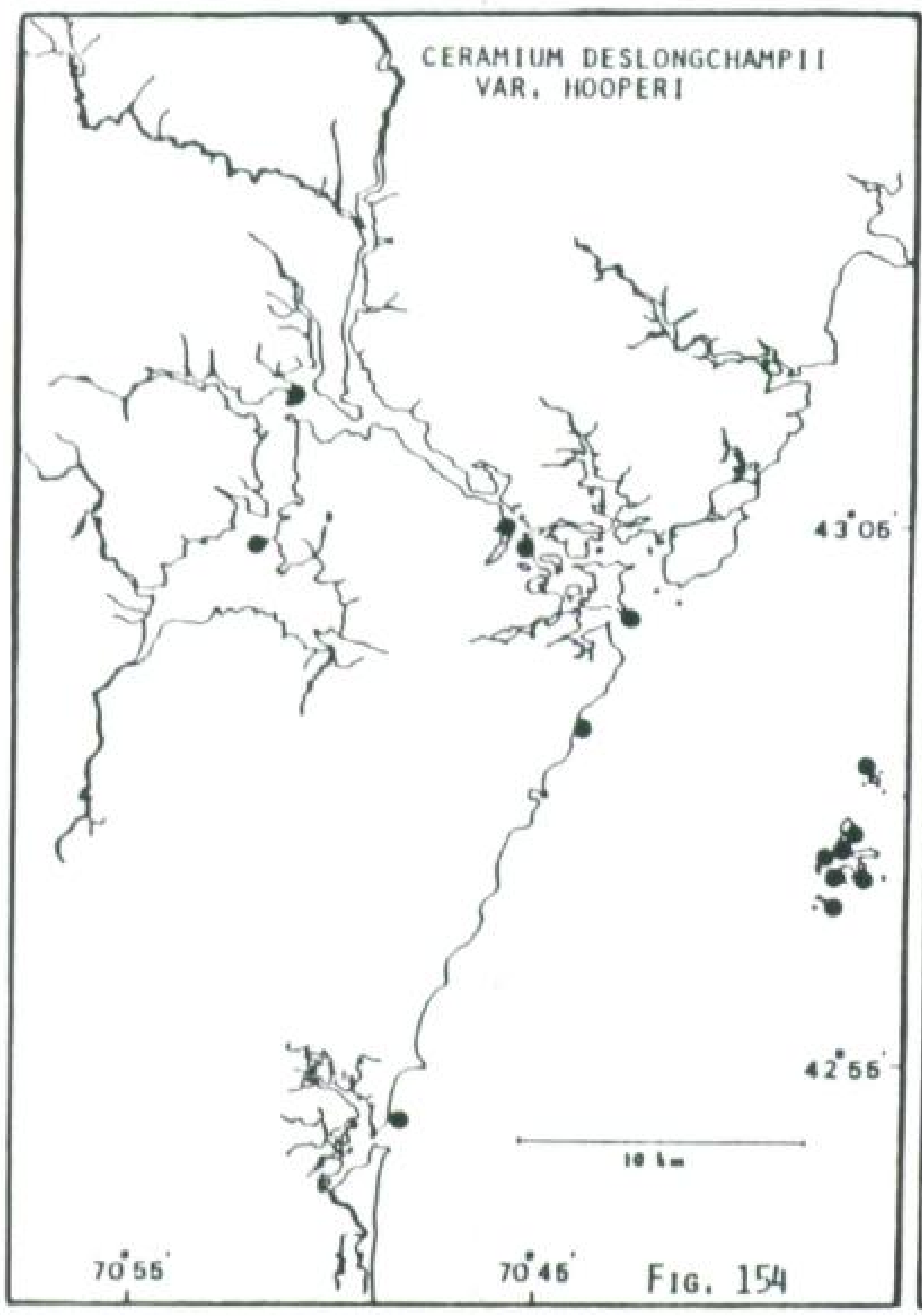
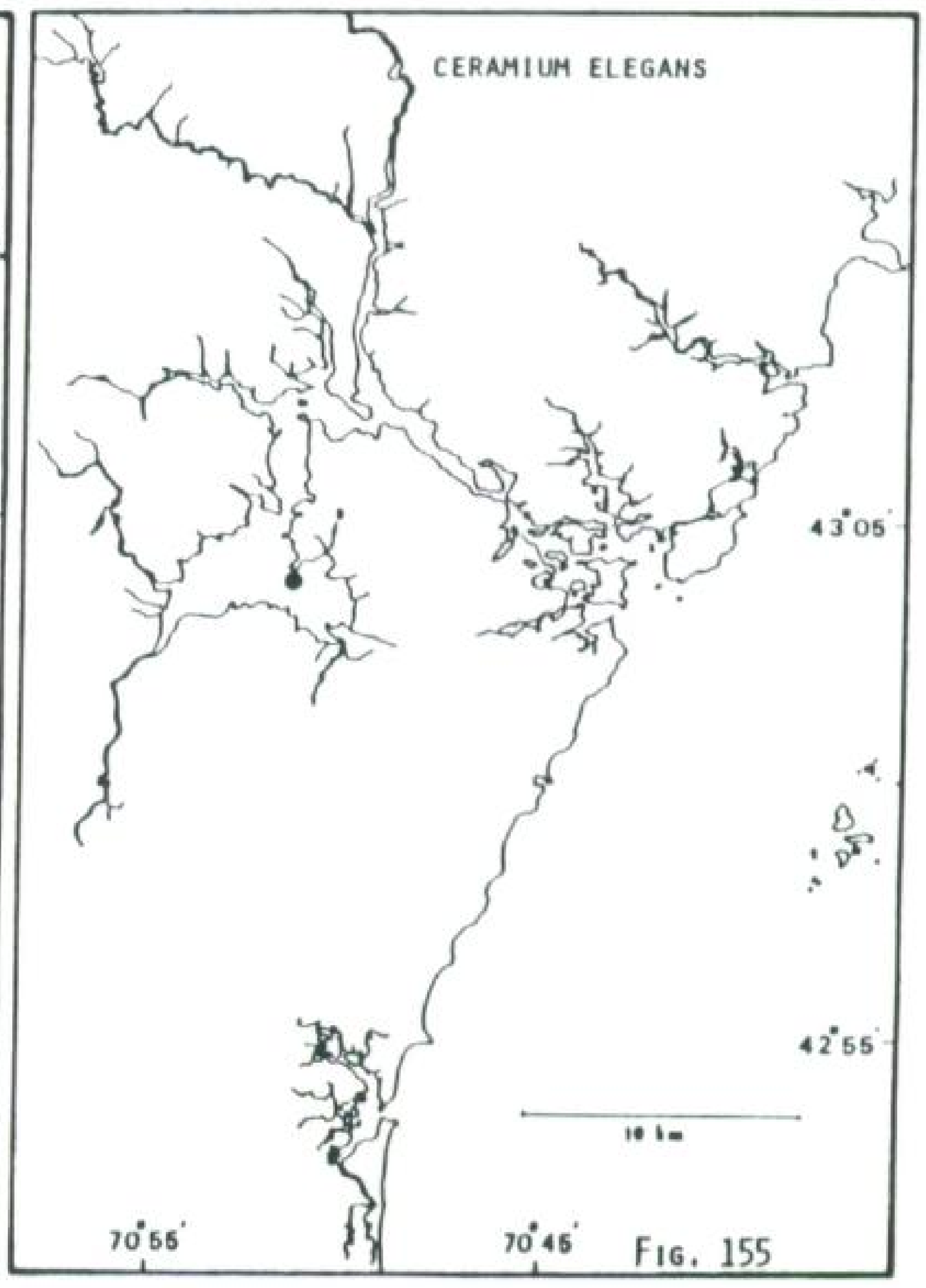


Fig. 151


CALLOCOLAX NEGLECTUS
43°05'
42°55'
10 km
70°55'
70°45'
FIG. 152


CALLOPHYLLIS CRISTATA
43°05'
42°55'
10 km
70°55'
70°45'
FIG. 153


CERAMIUM DESLONGCHAMPII
VAR. HOOPERI
43°05'
42°55'
10 km
70°55'
70°45'
FIG. 154


CERAMIUM ELEGANS
43°05'
42°55'
10 km
70°55'
70°45'
FIG. 155

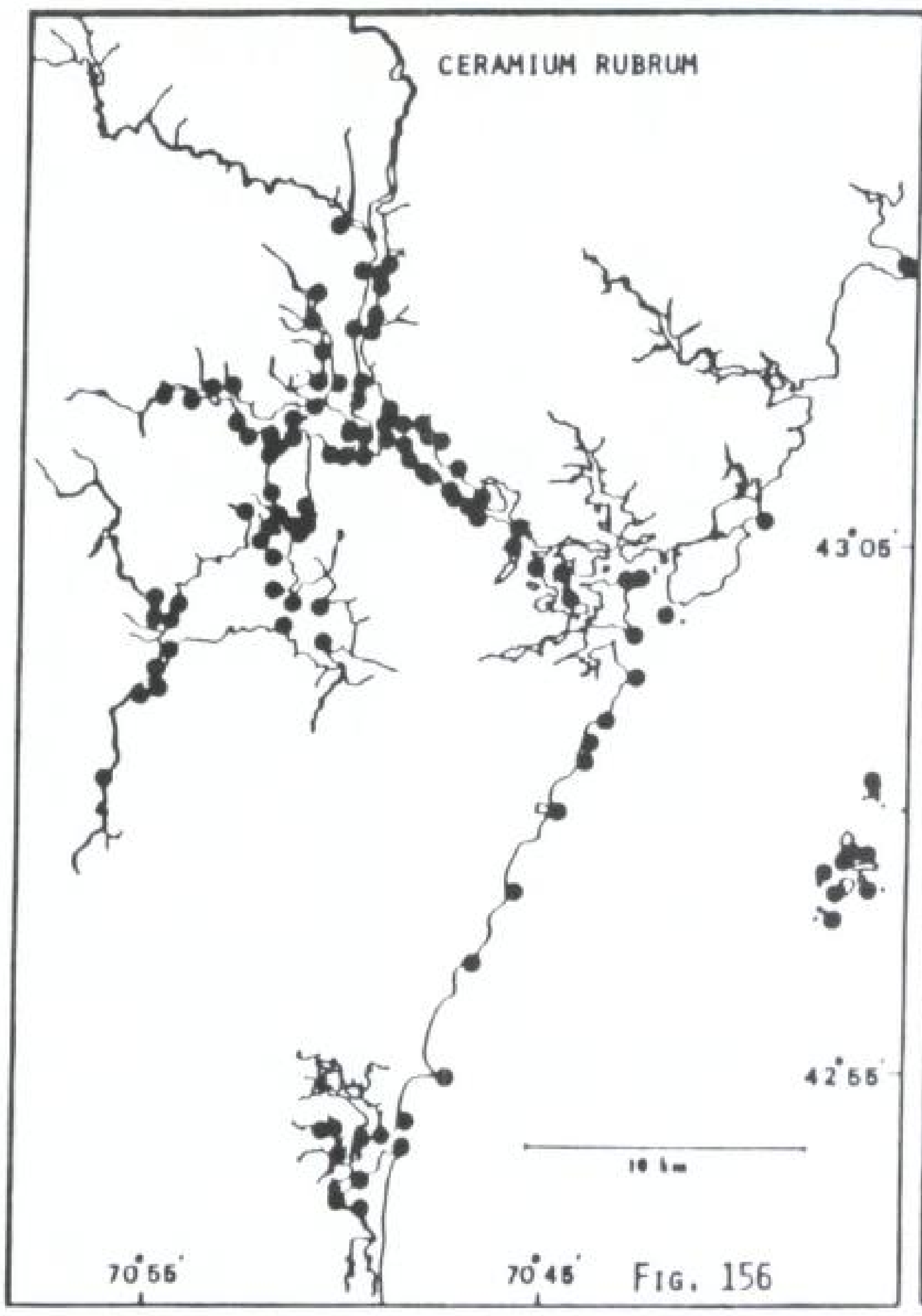


FIG. 156

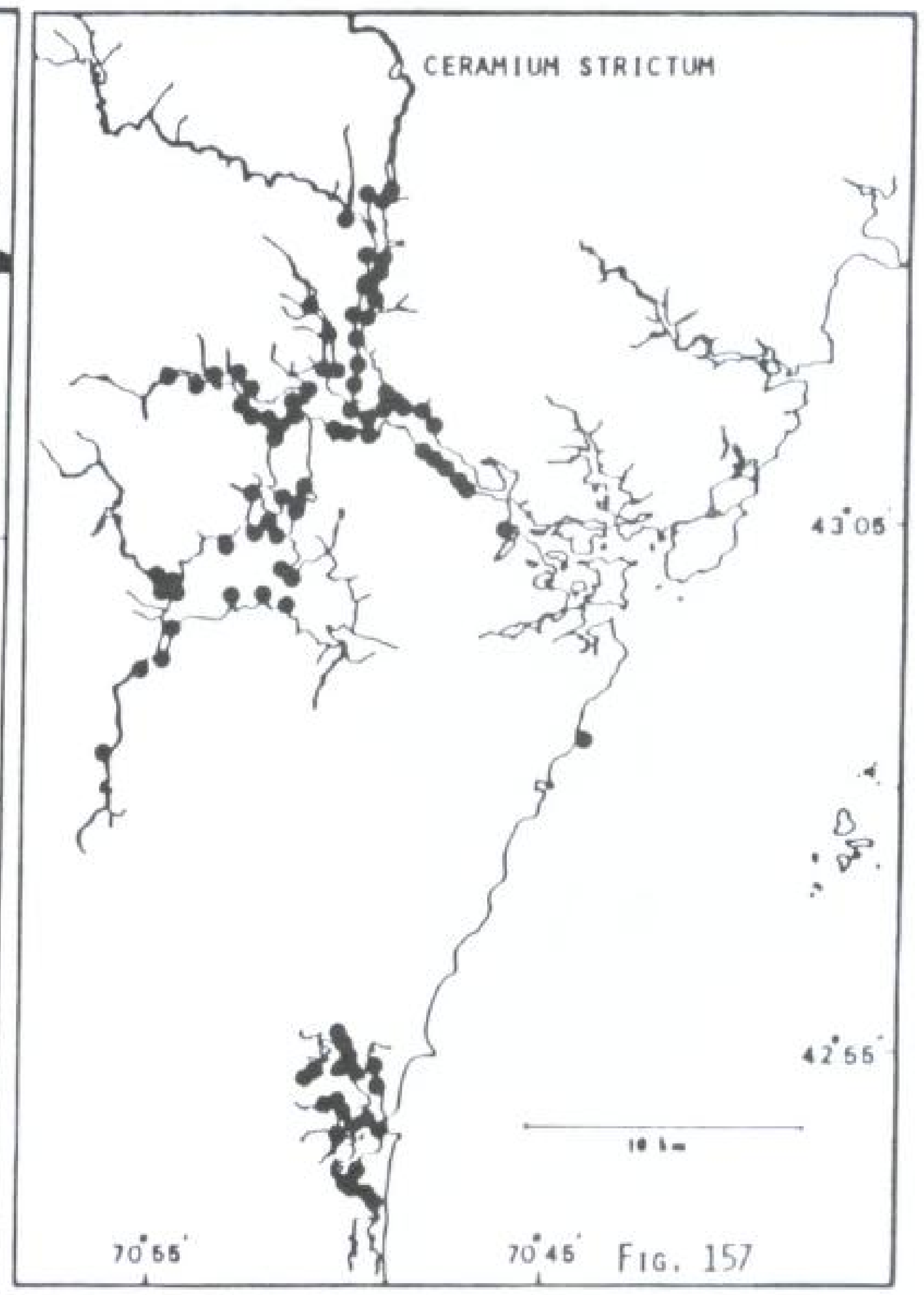


FIG. 157

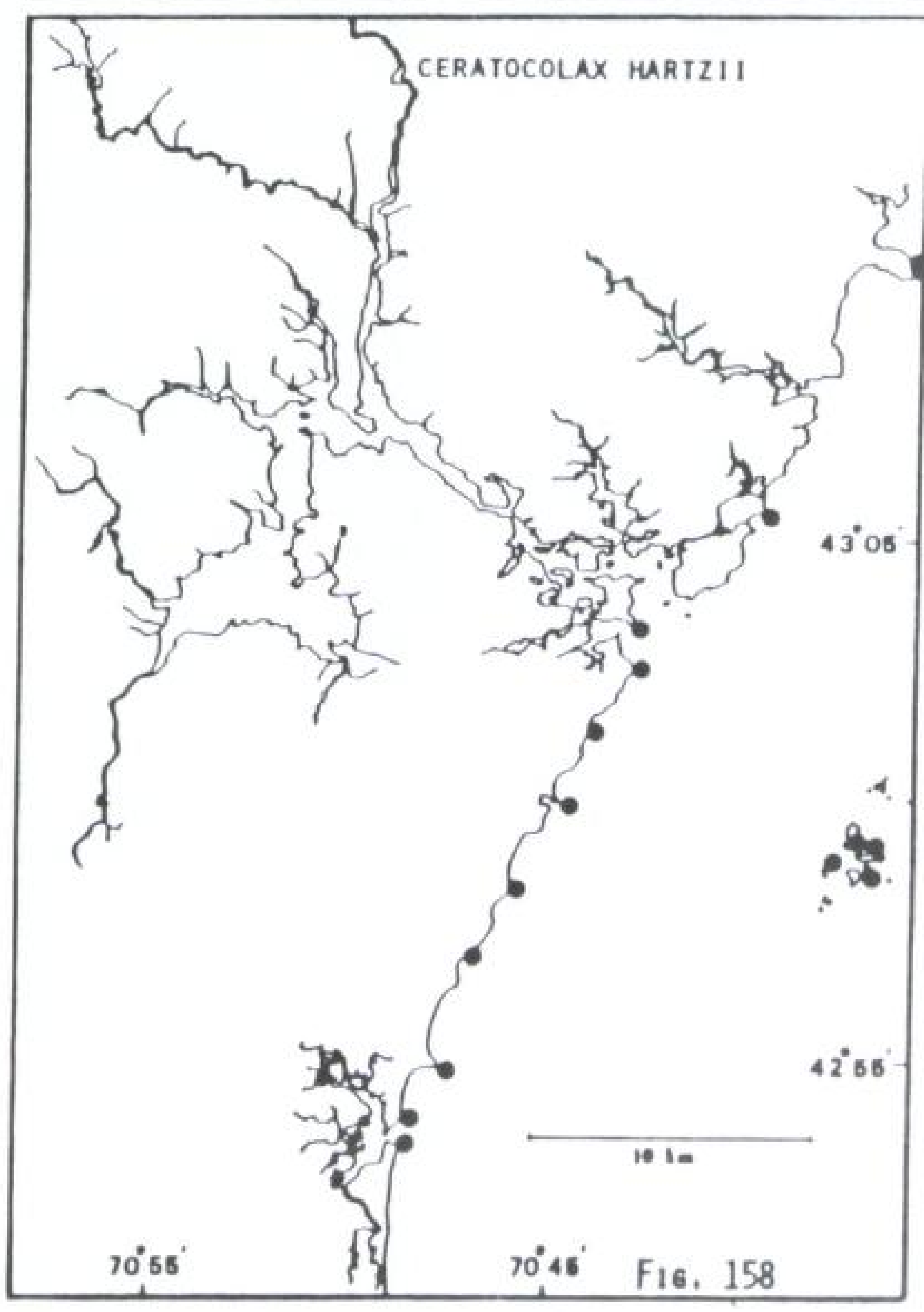


FIG. 158

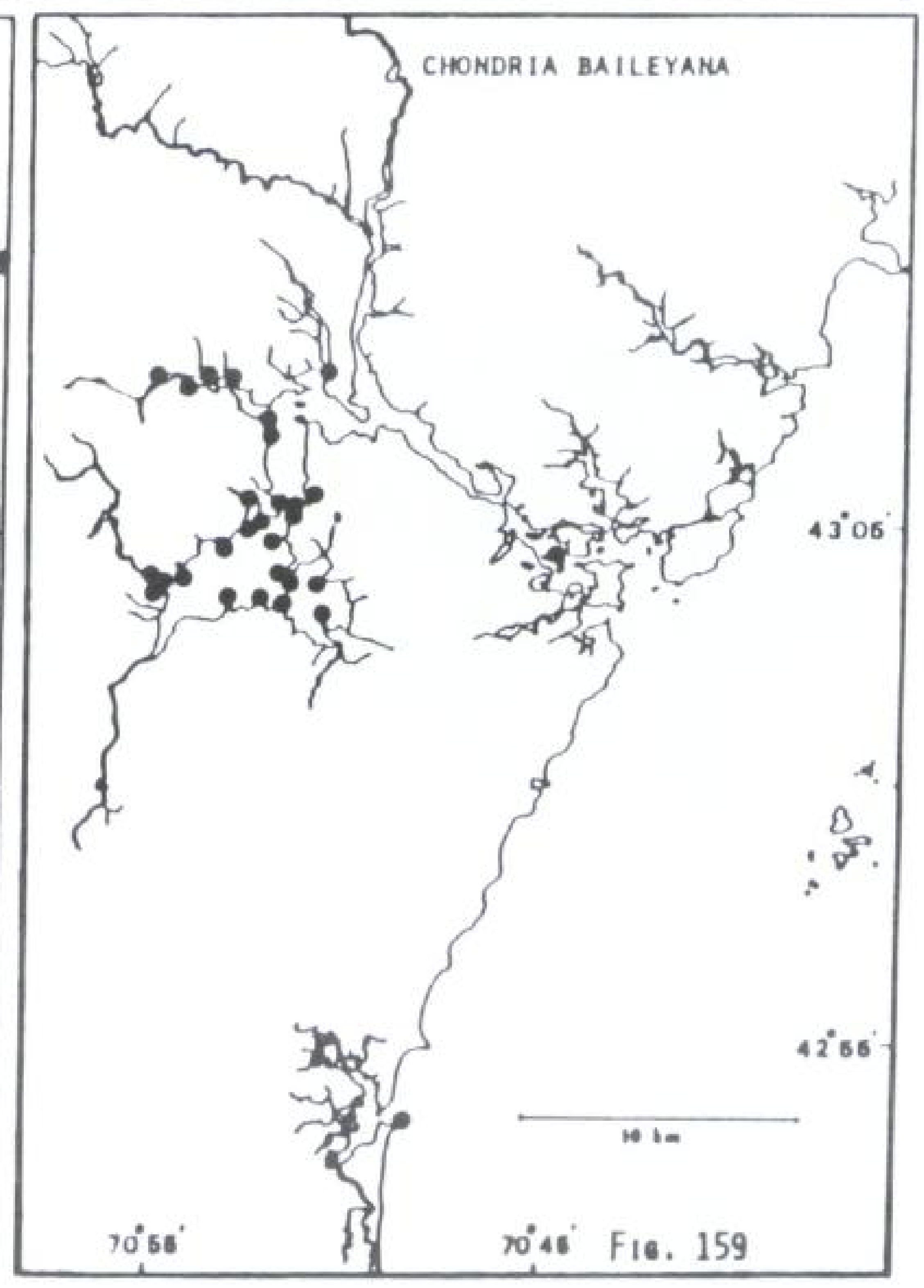


FIG. 159

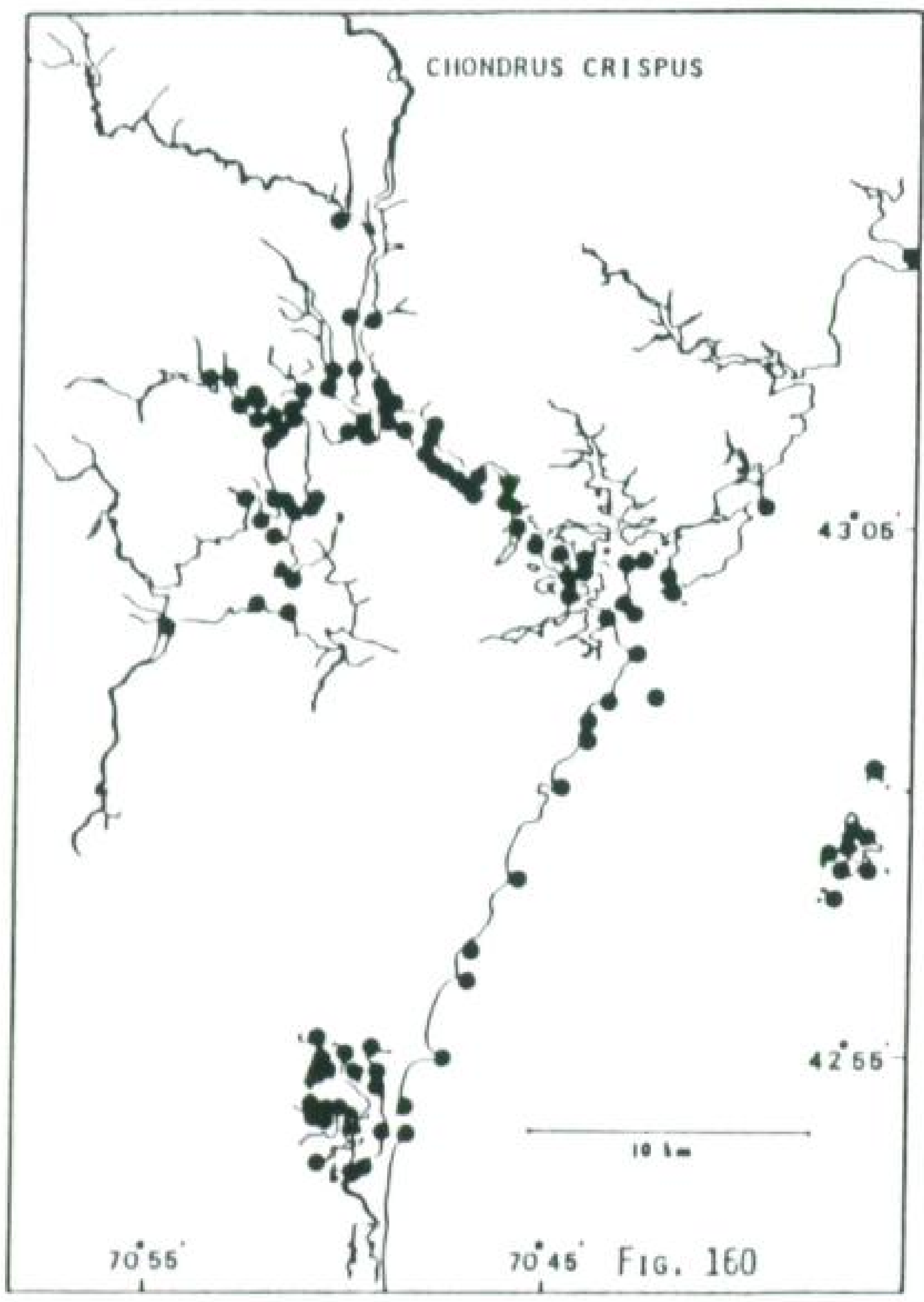


Fig. 160

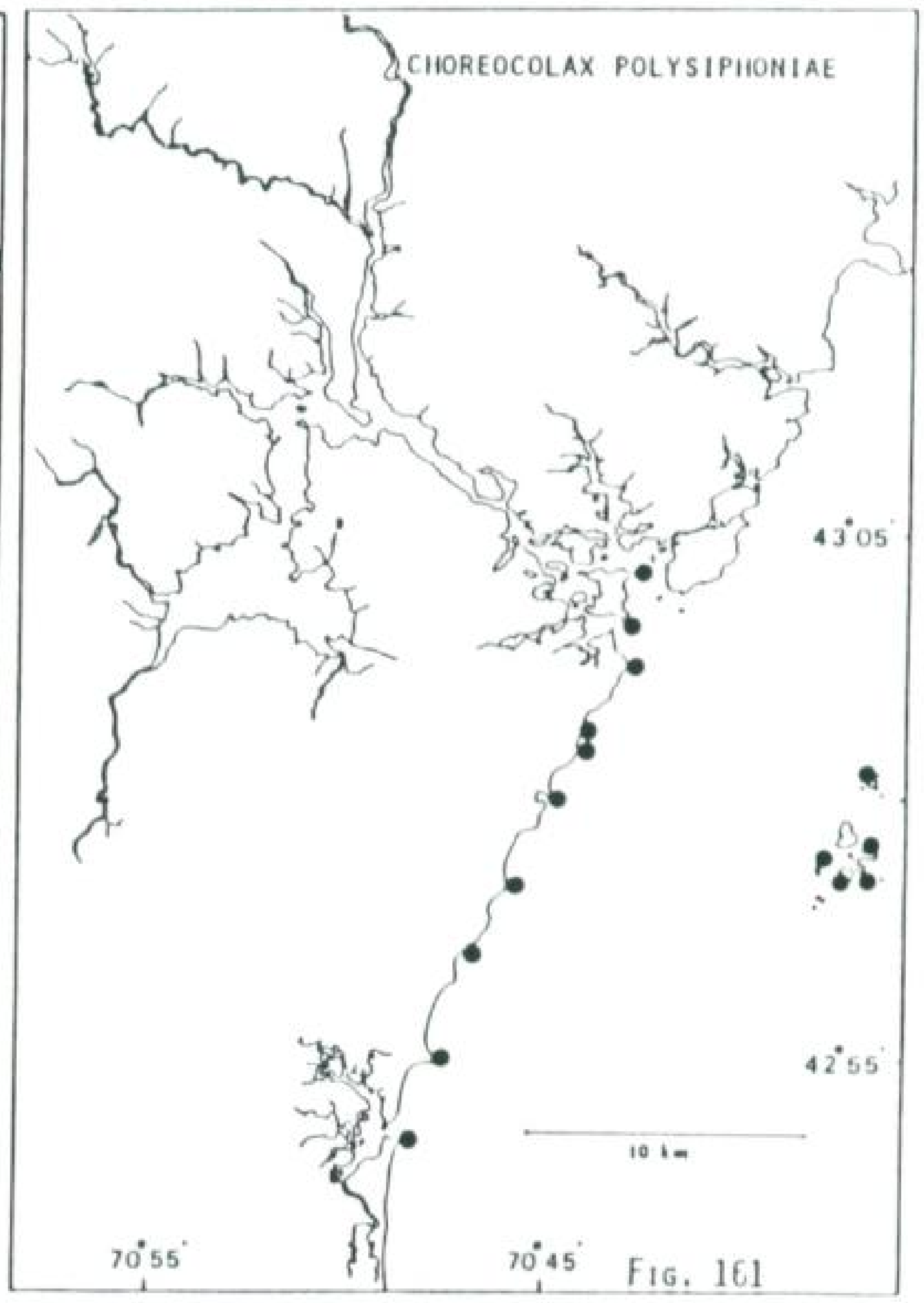


Fig. 161

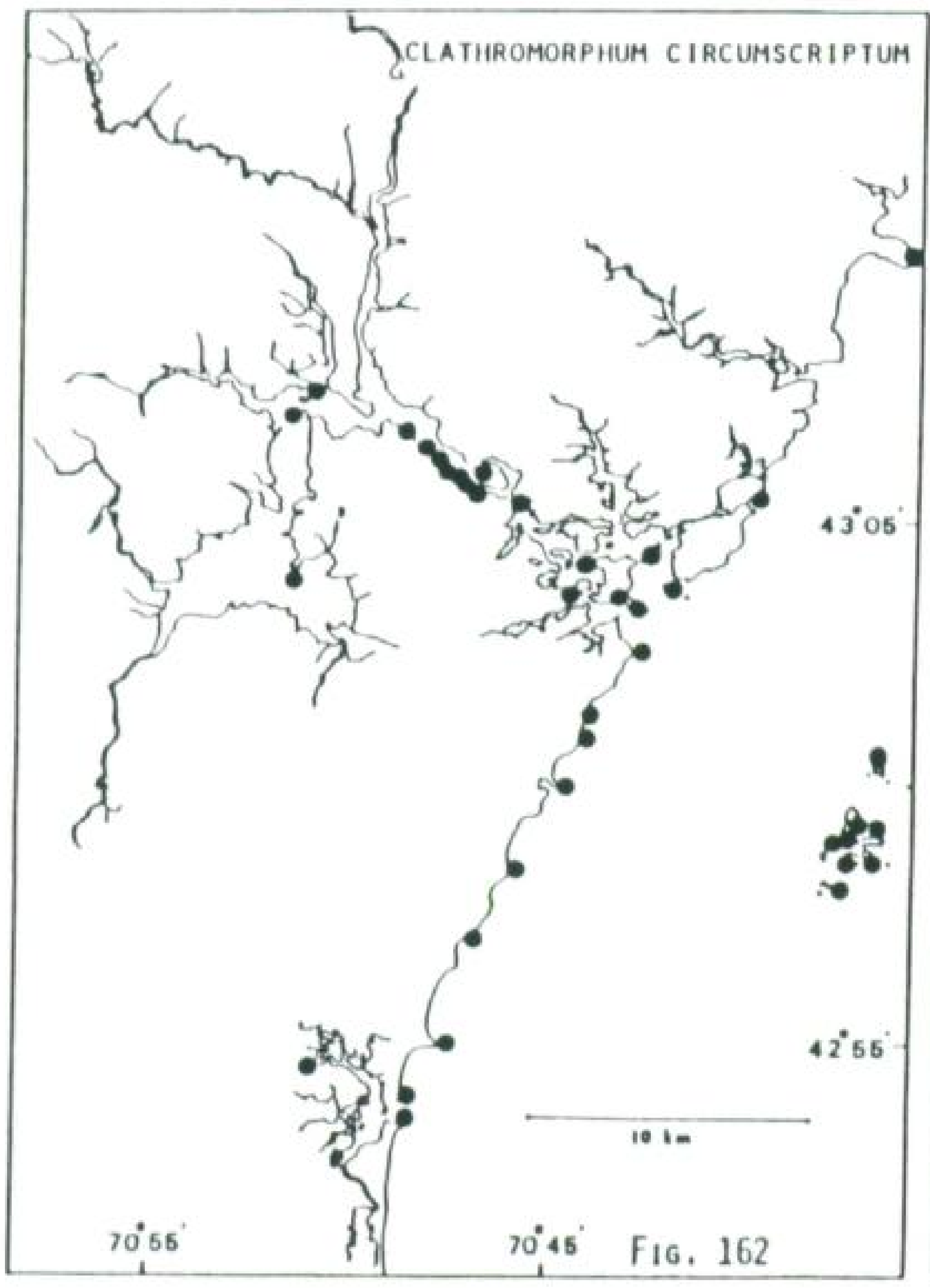


Fig. 162

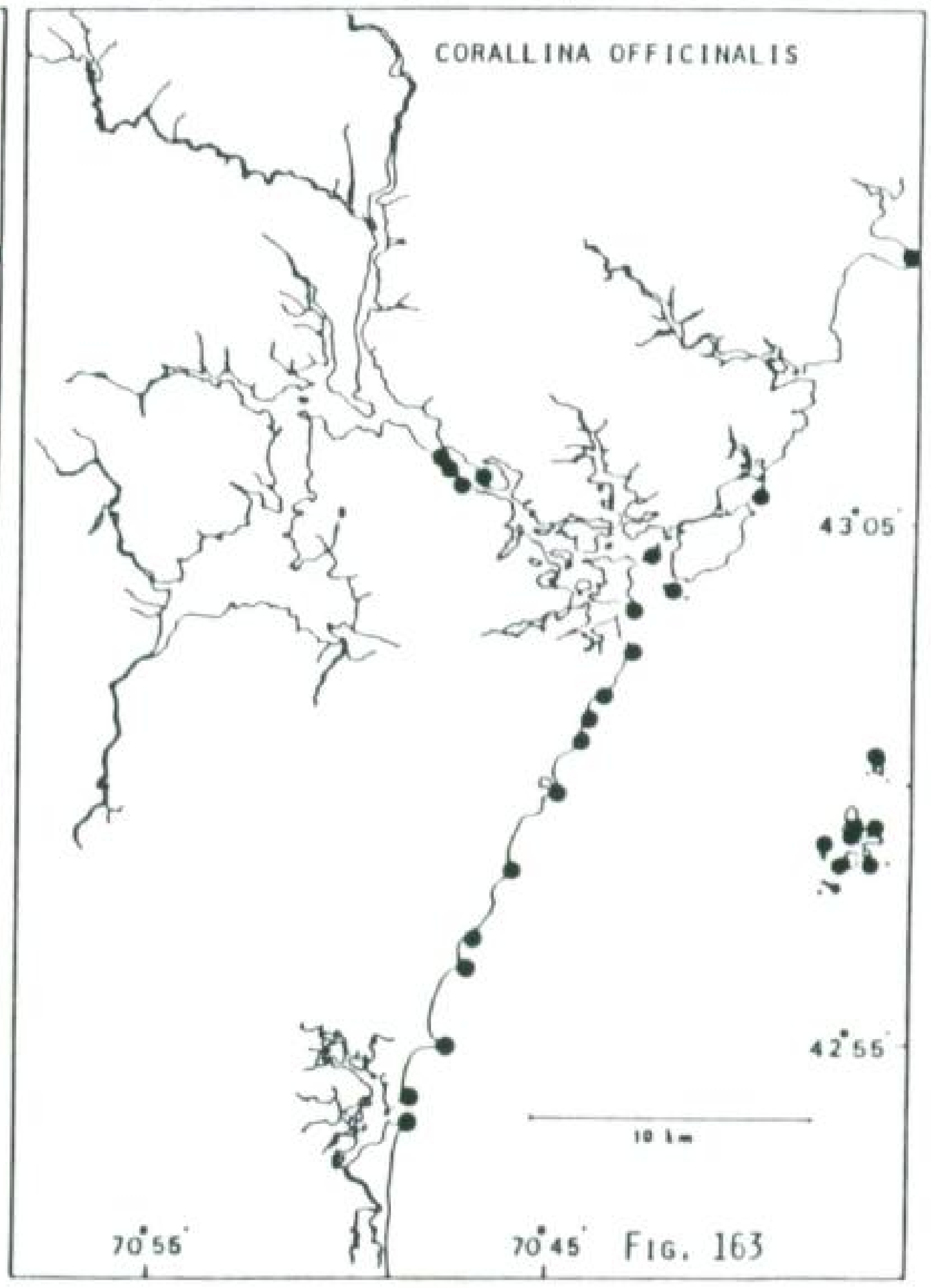


Fig. 163

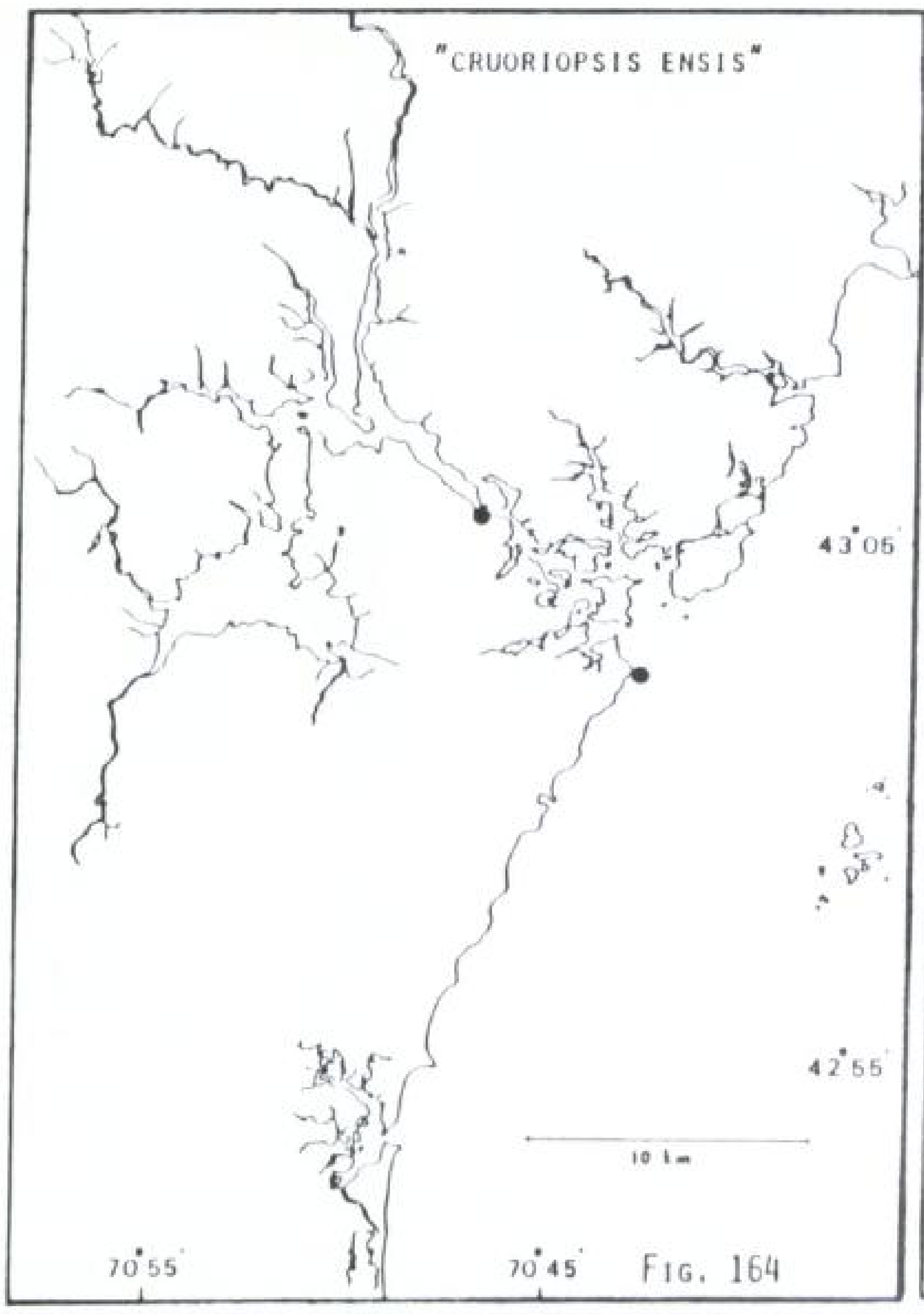


FIG. 164

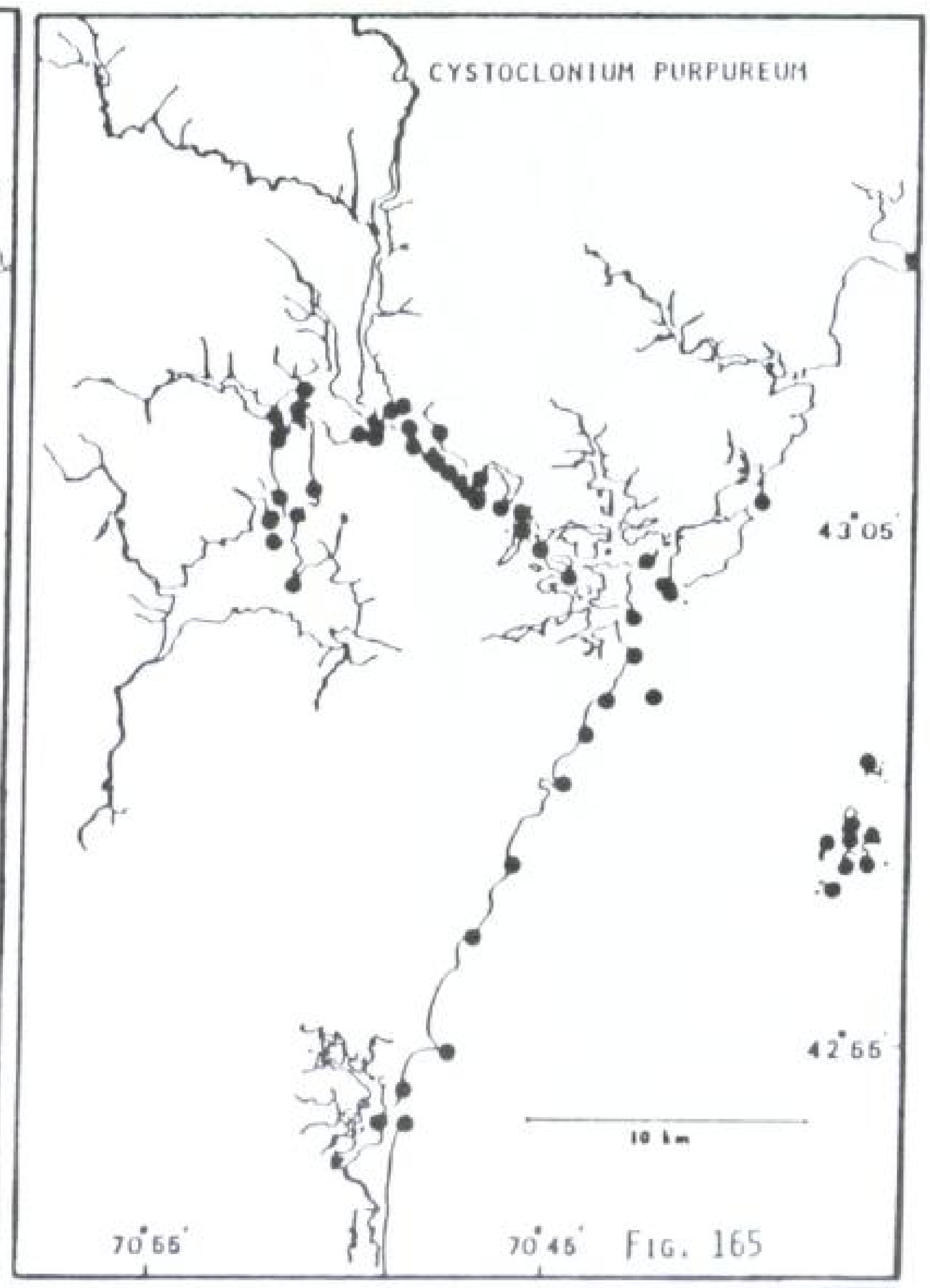


FIG. 165

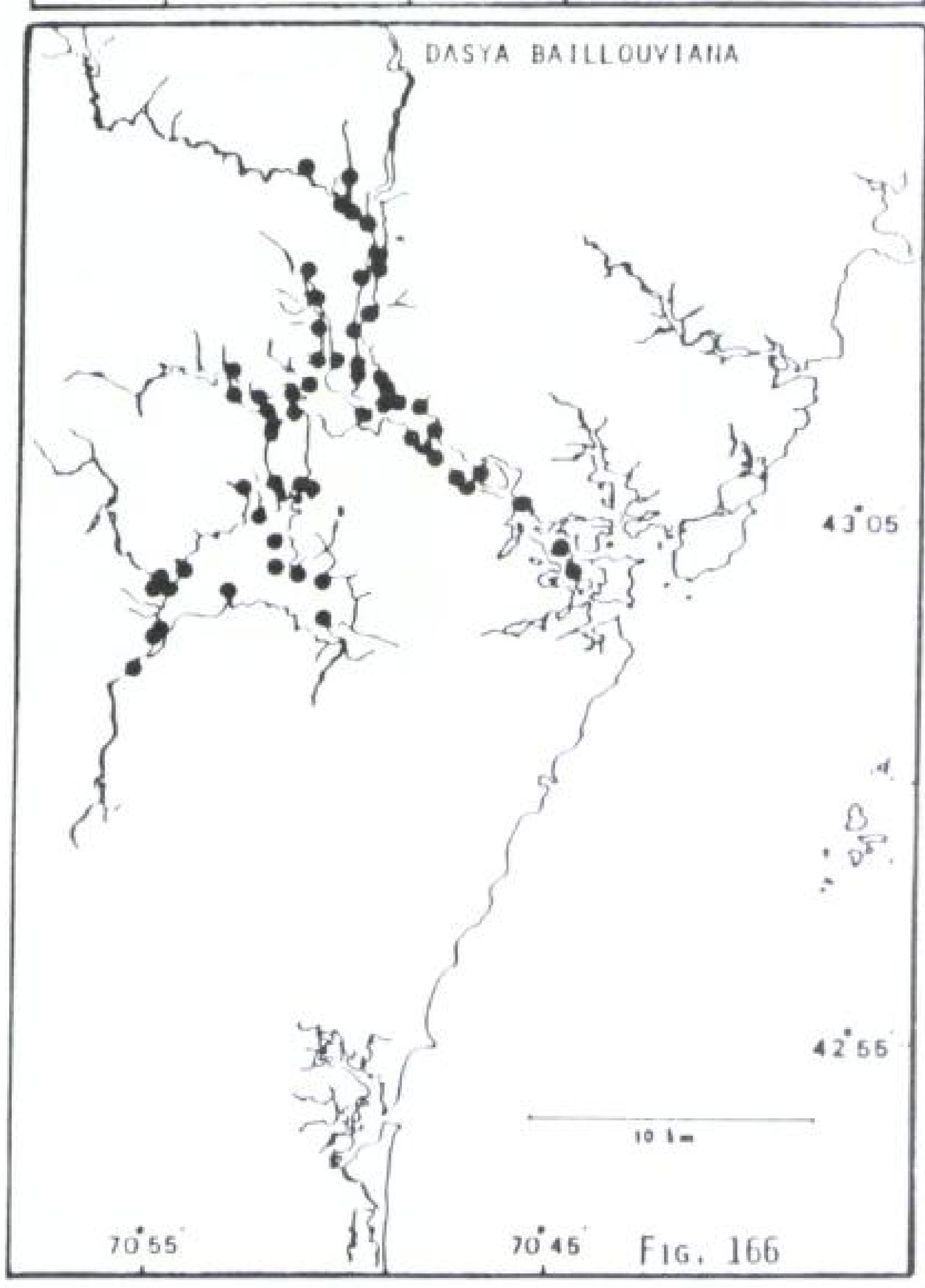


FIG. 166

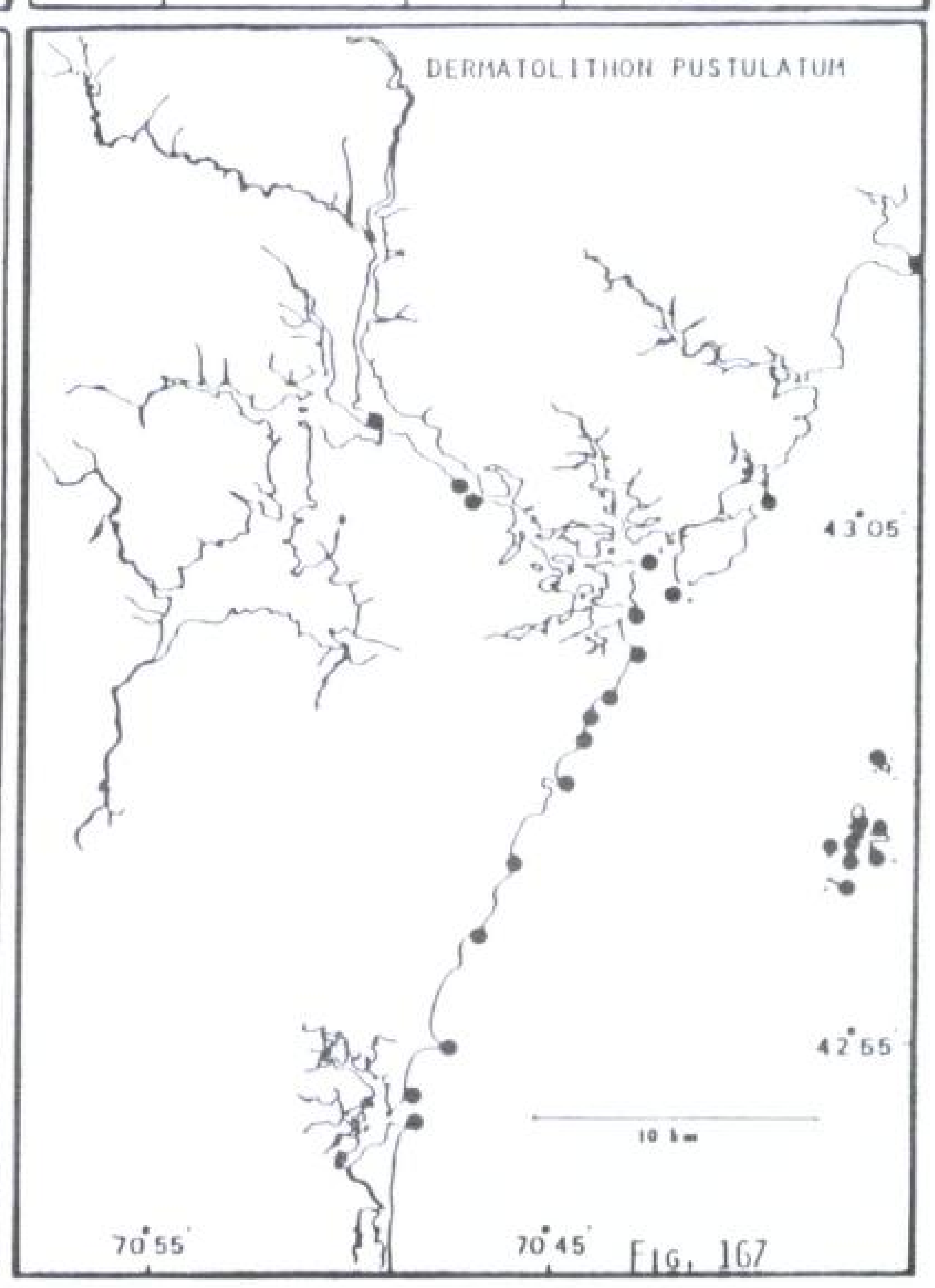


FIG. 167

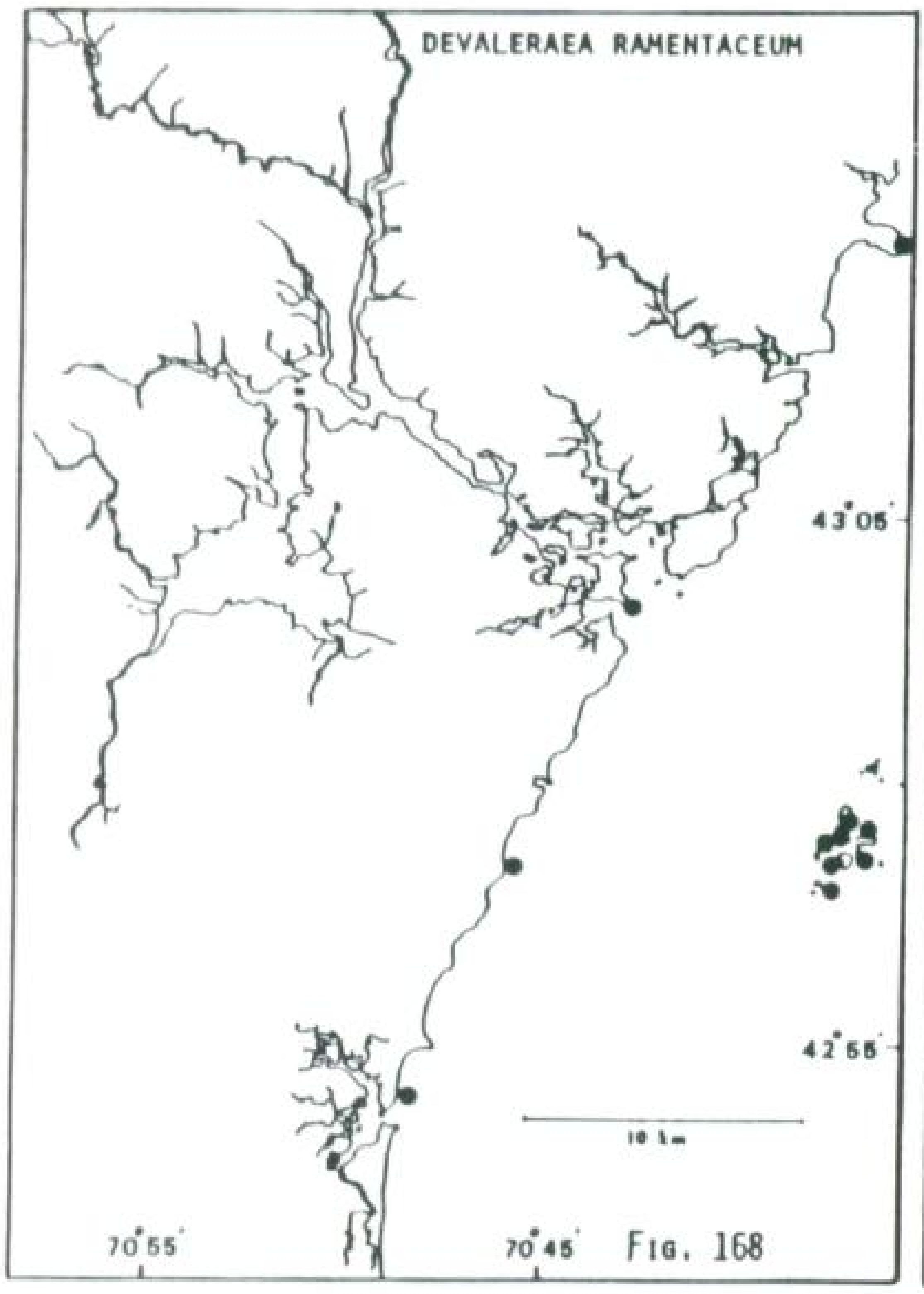


Fig. 168

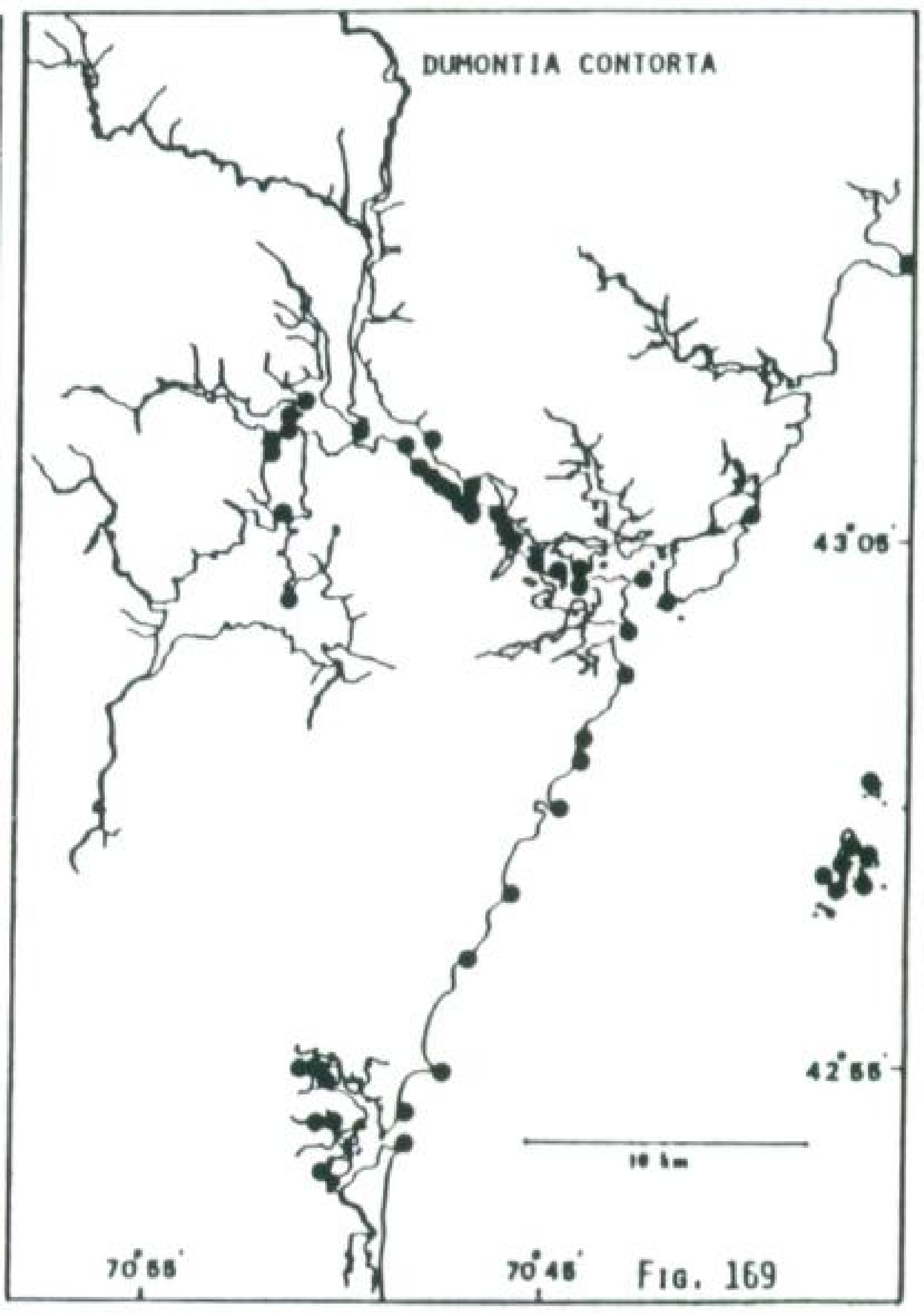


Fig. 169

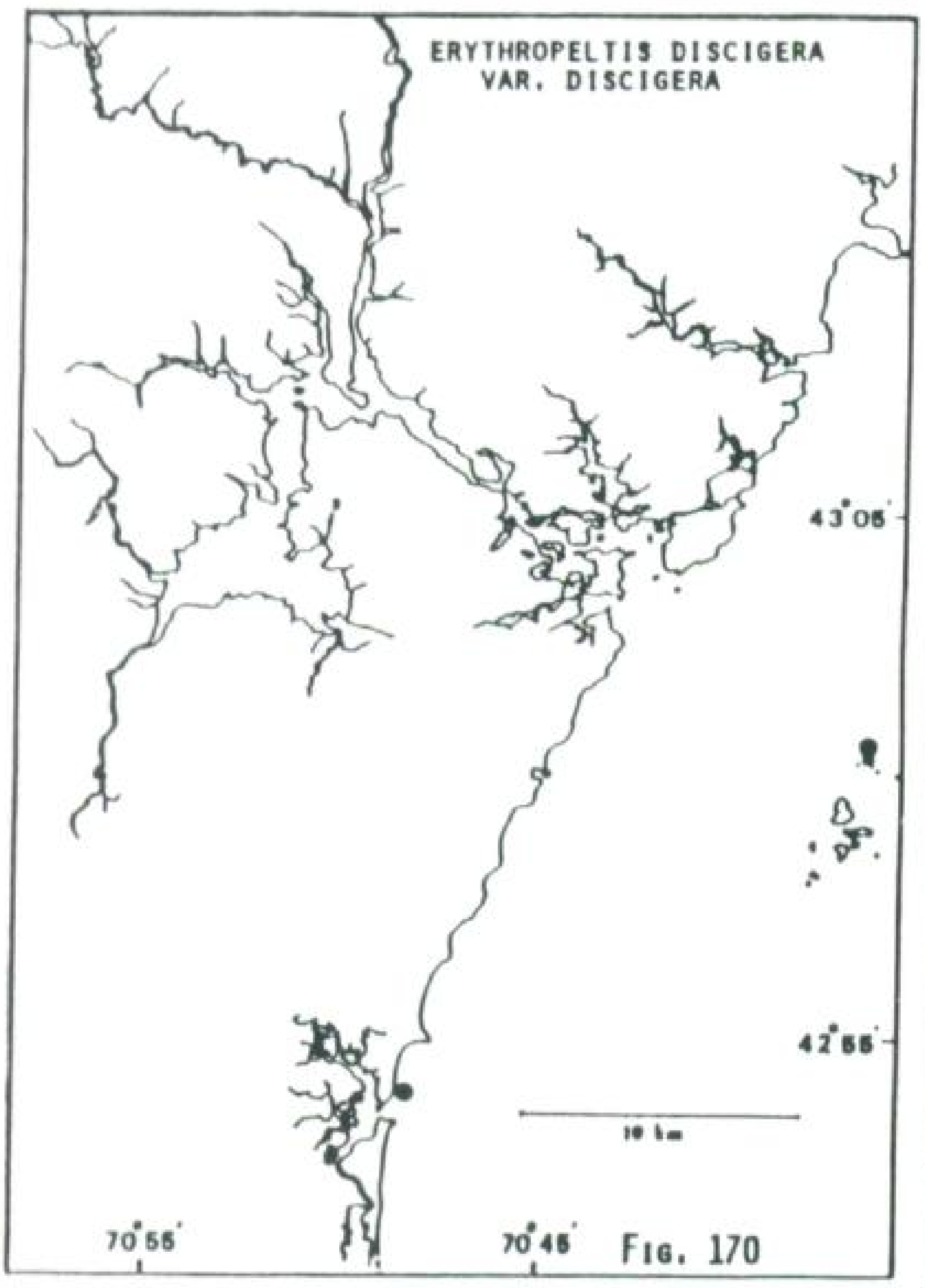


Fig. 170

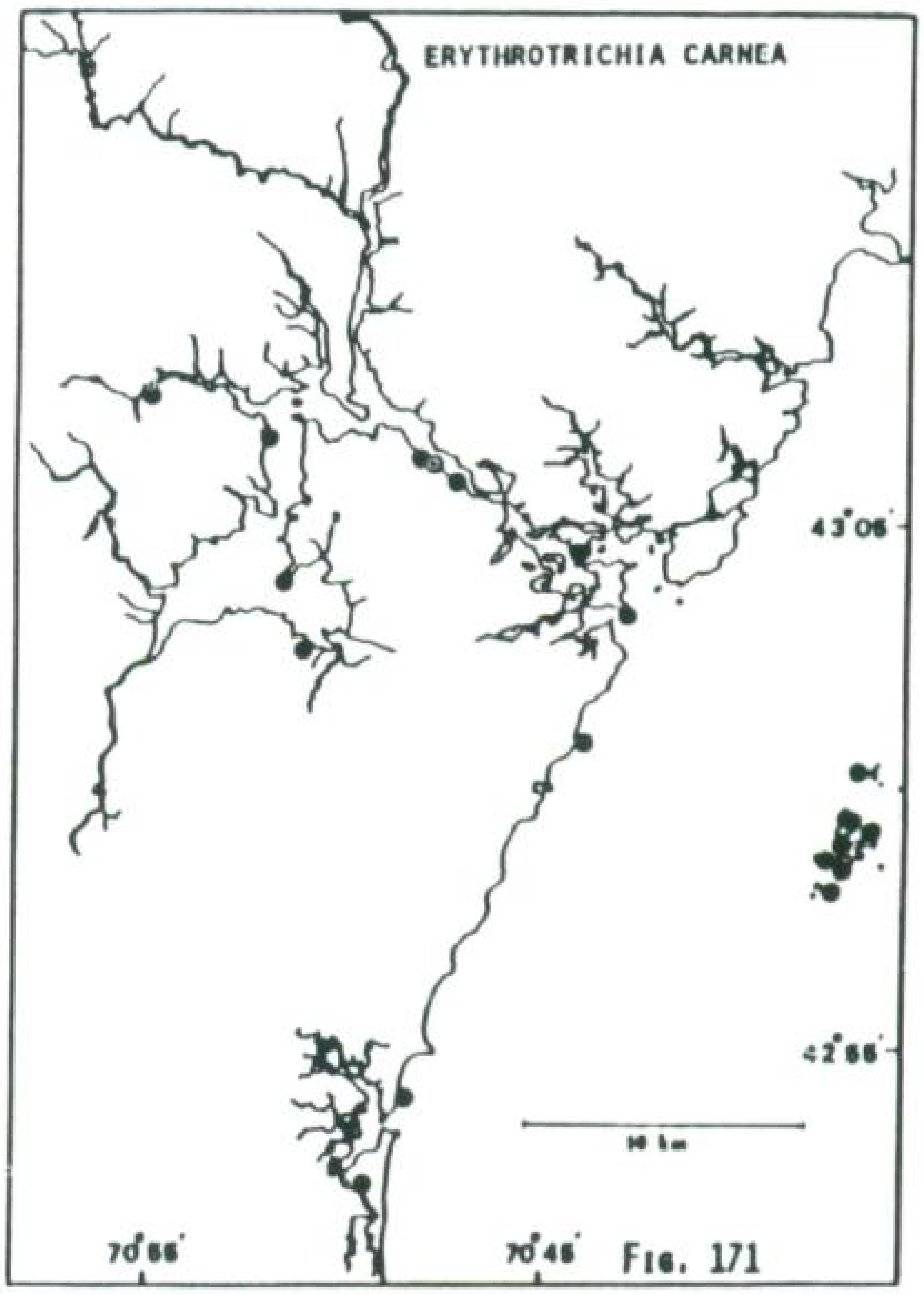


Fig. 171

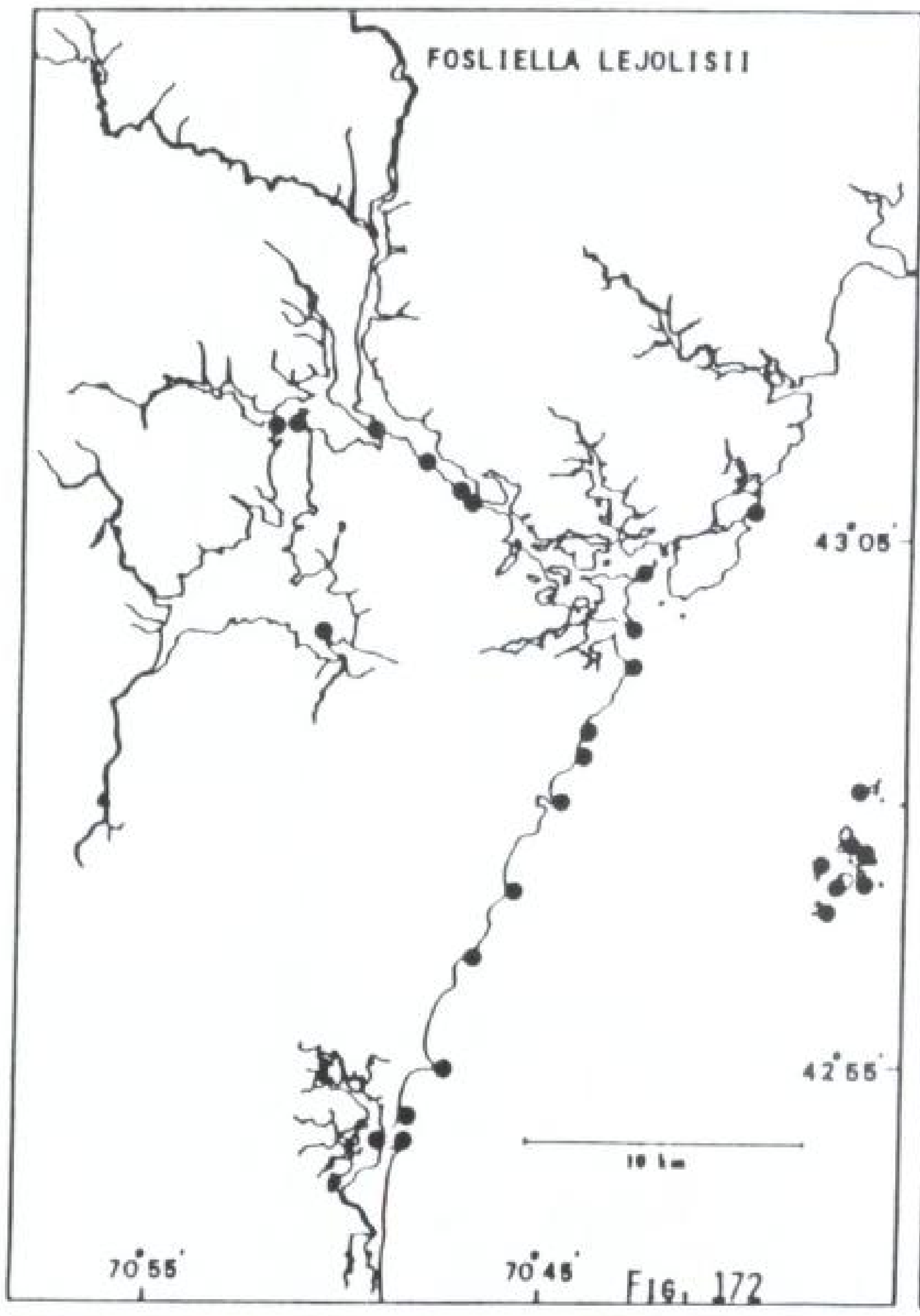


Fig. 172

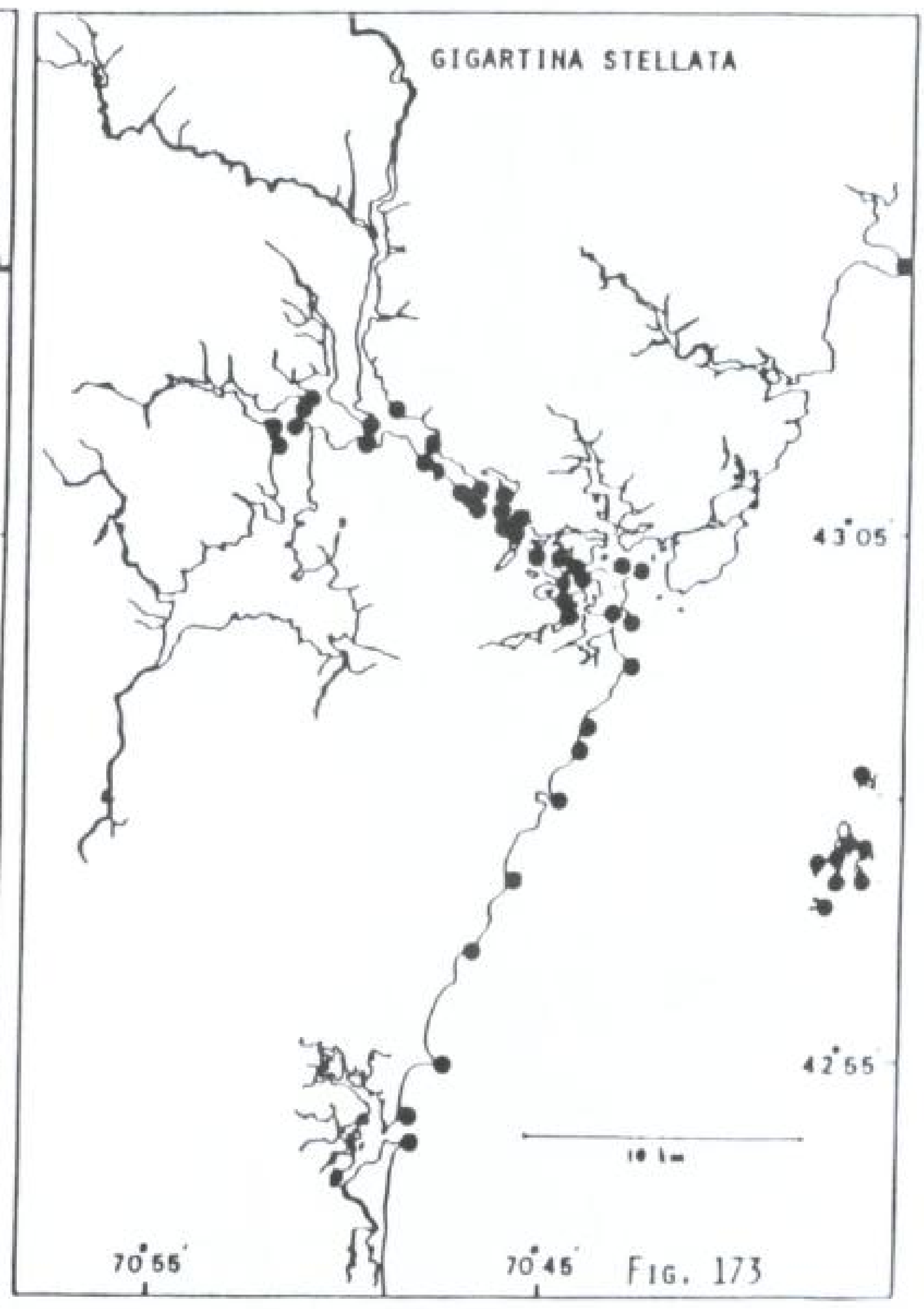


Fig. 173

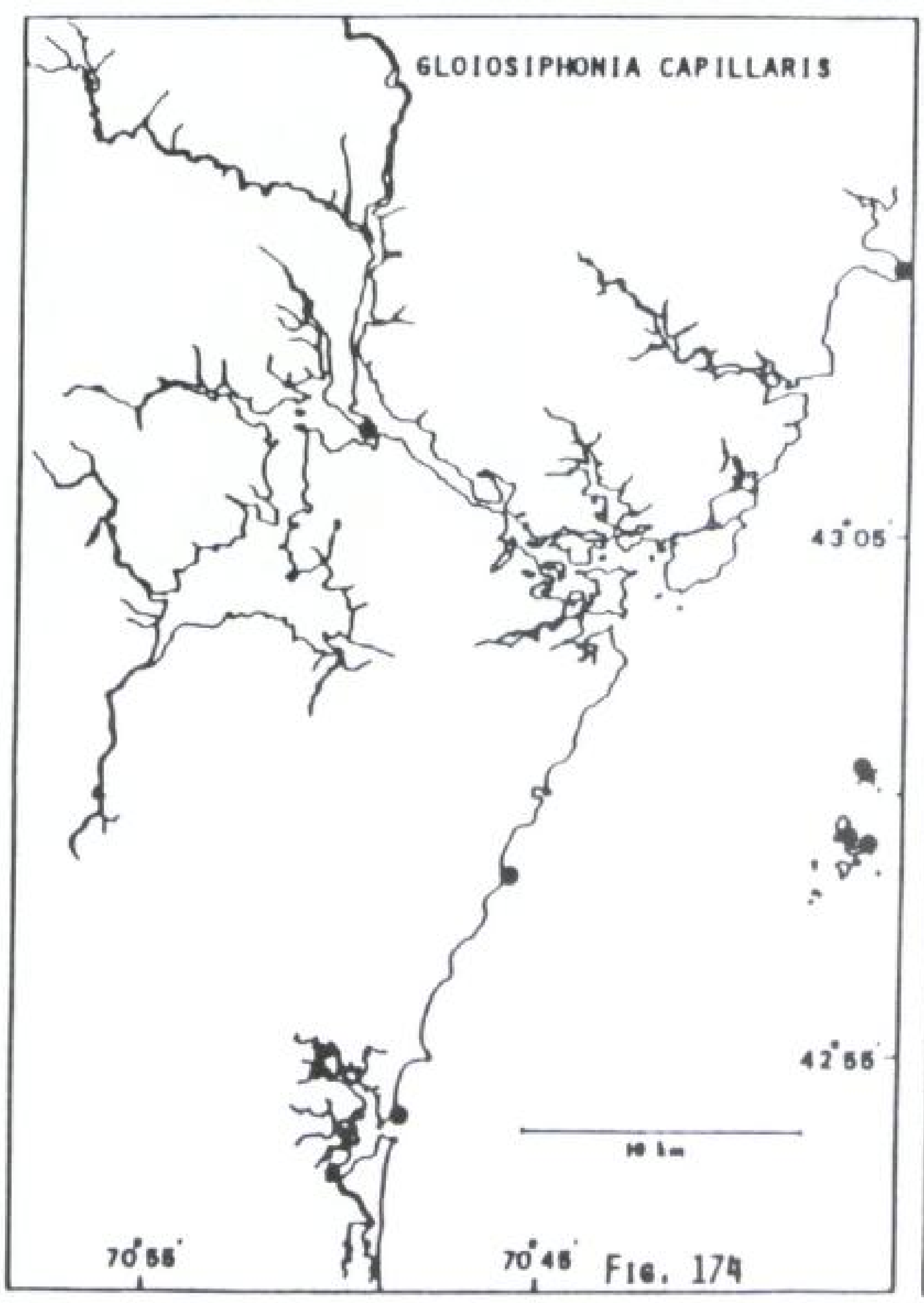


Fig. 174

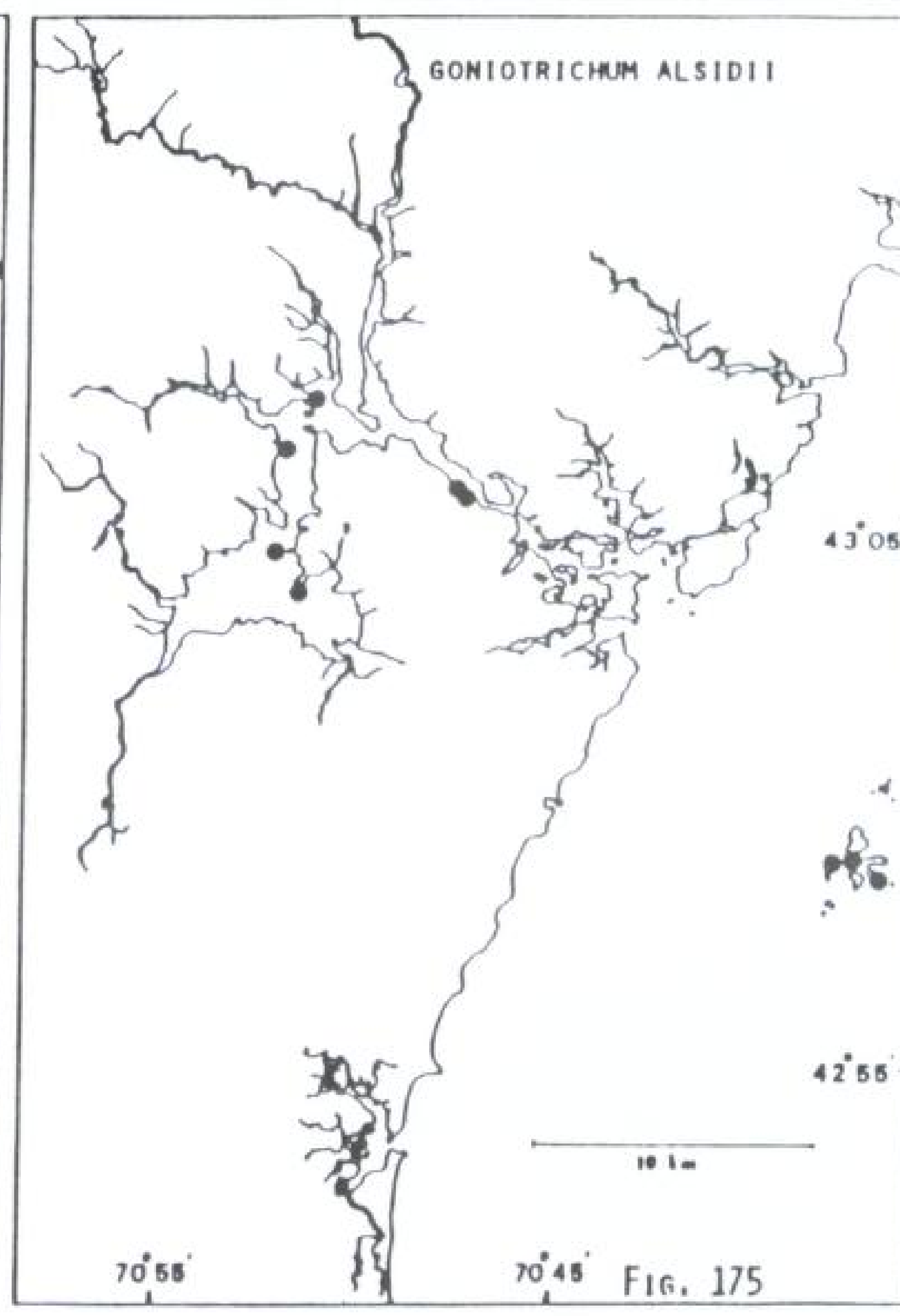


Fig. 175

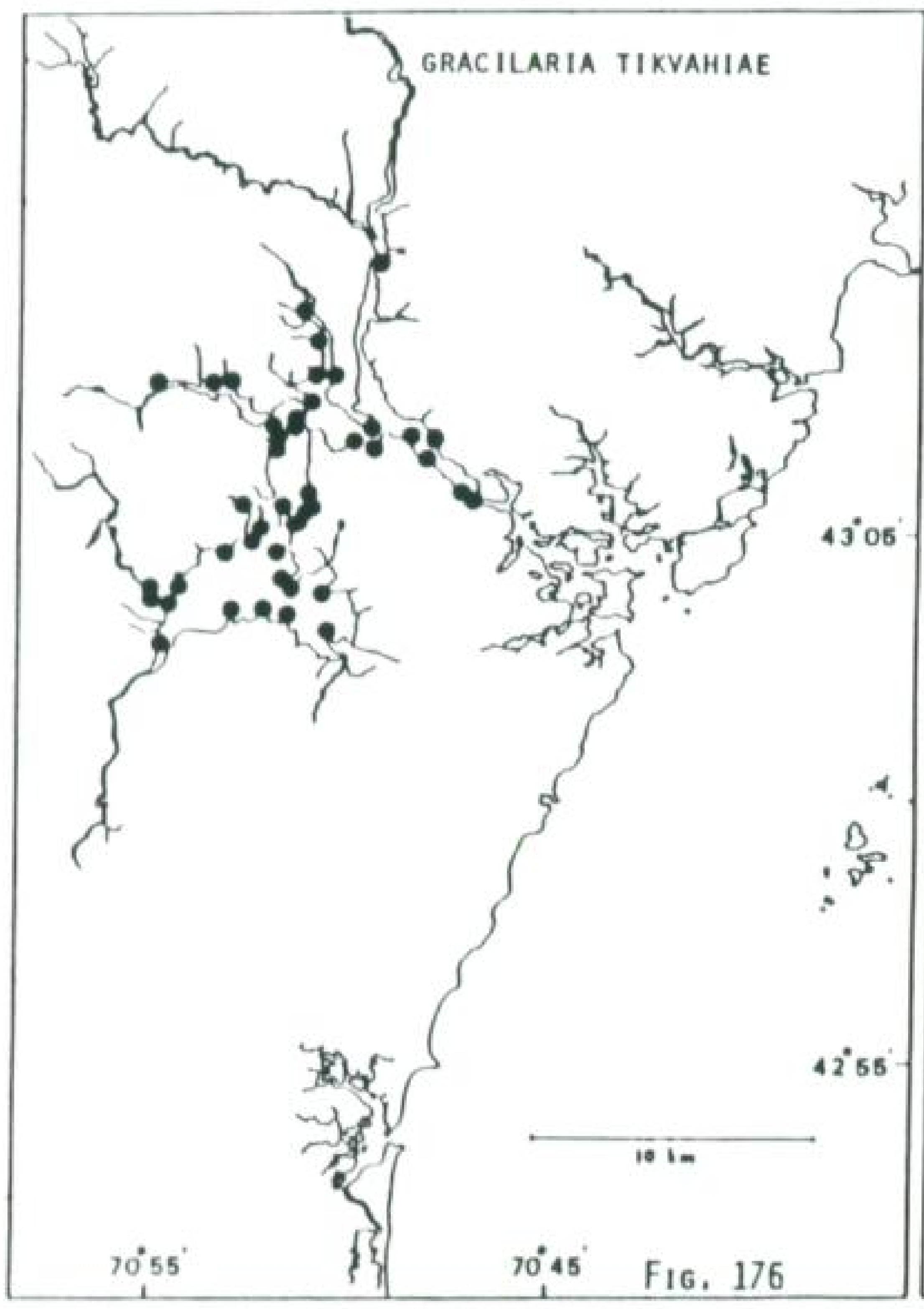


Fig. 176

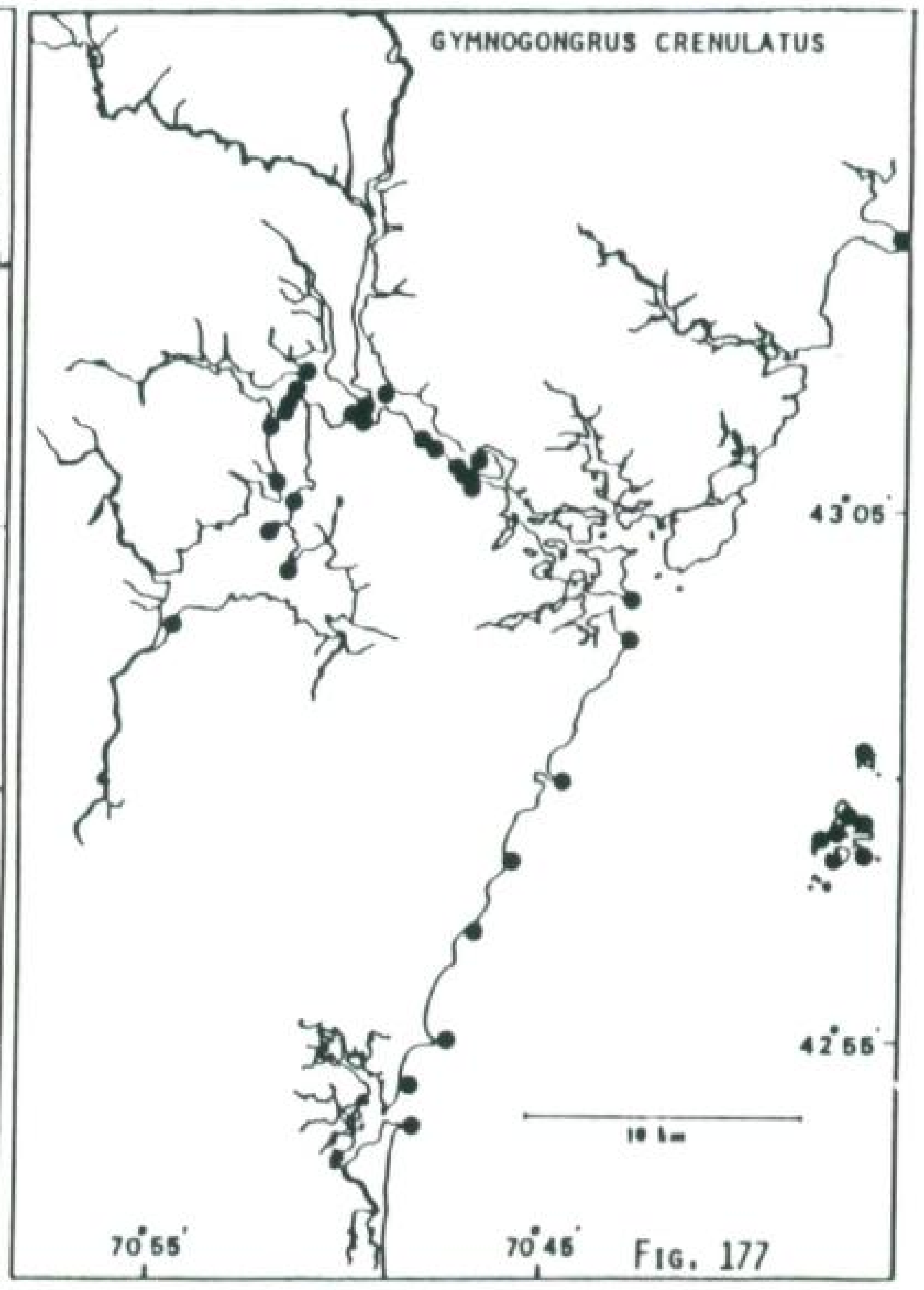


Fig. 177

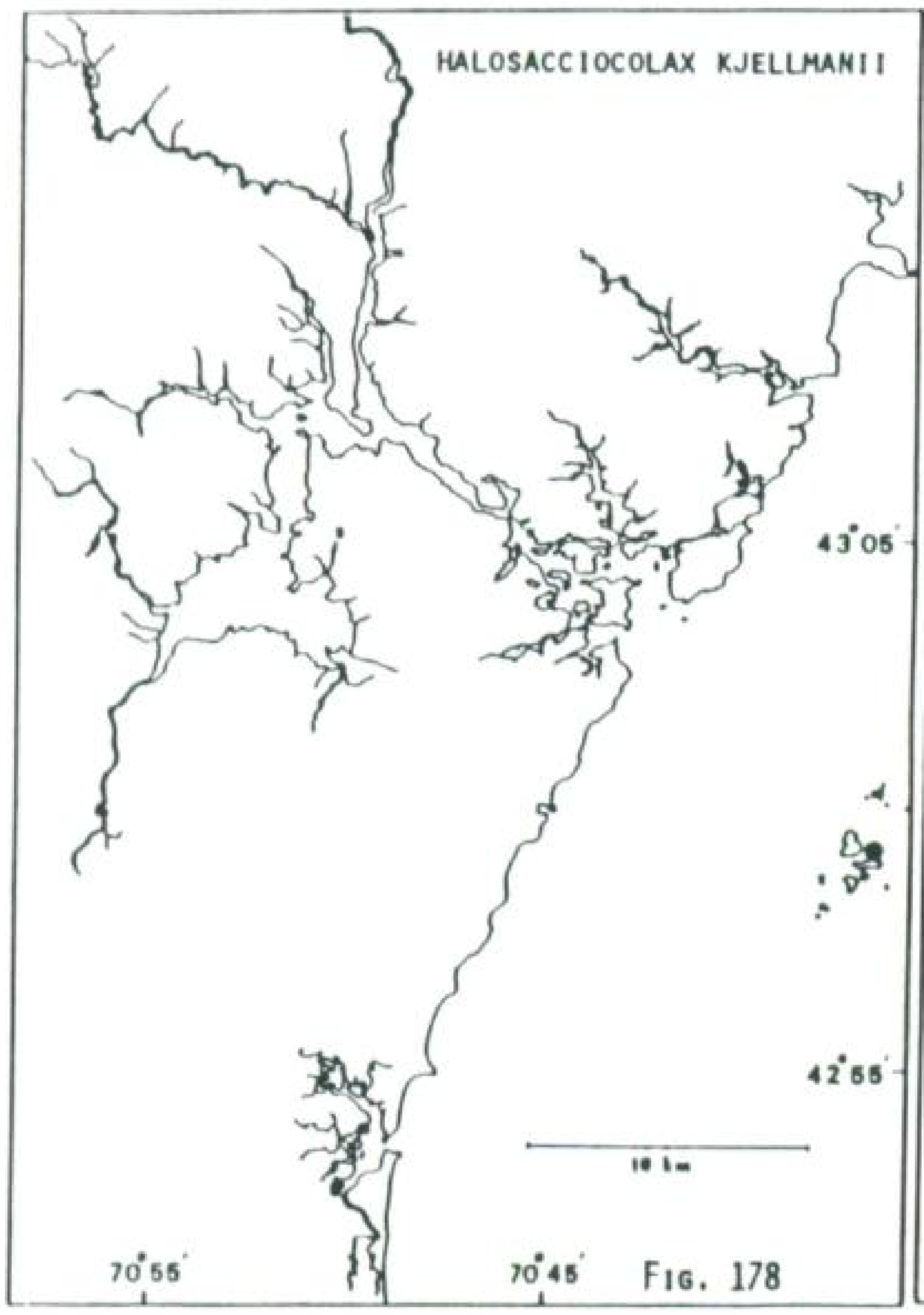


Fig. 178

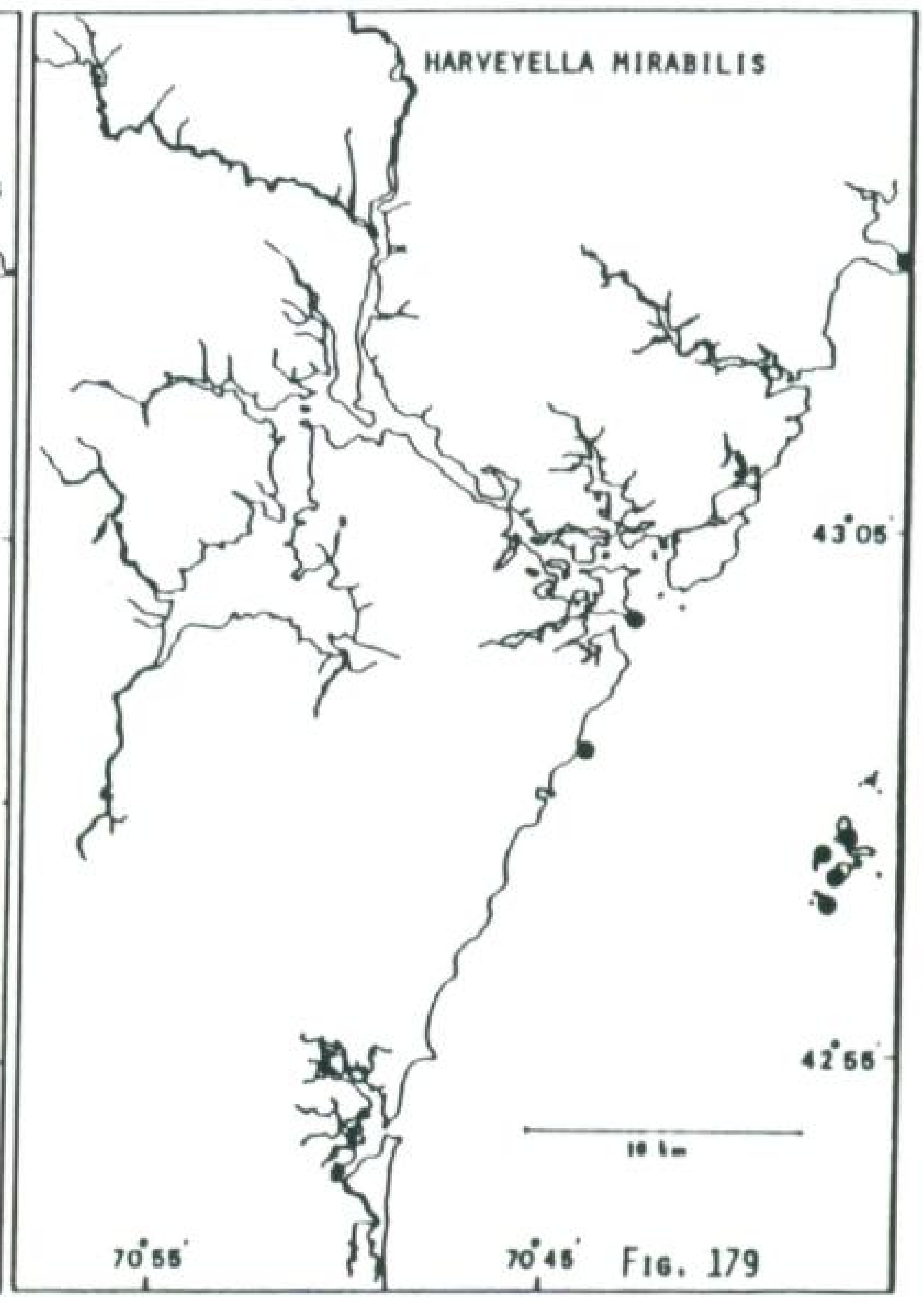


Fig. 179

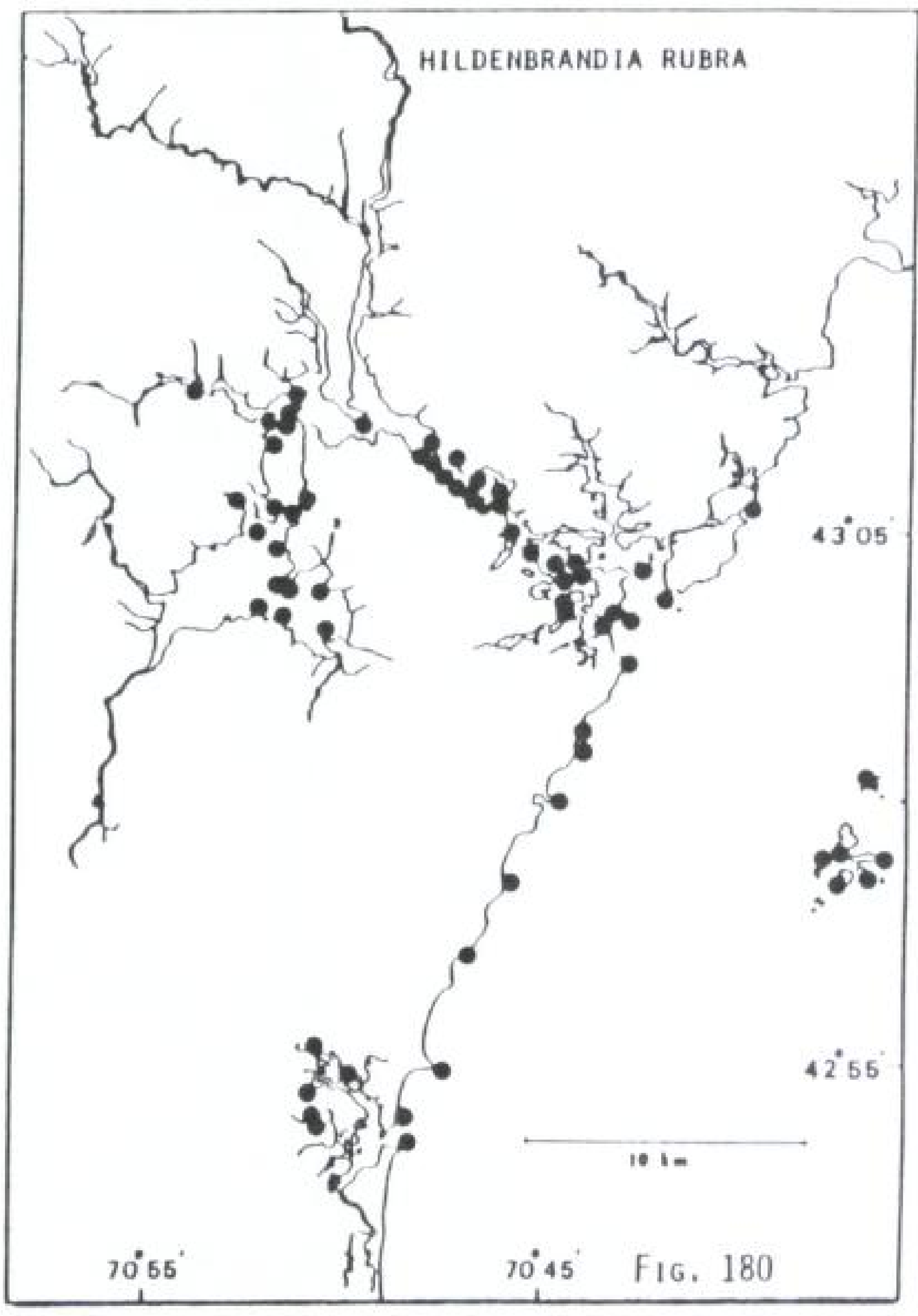


FIG. 180

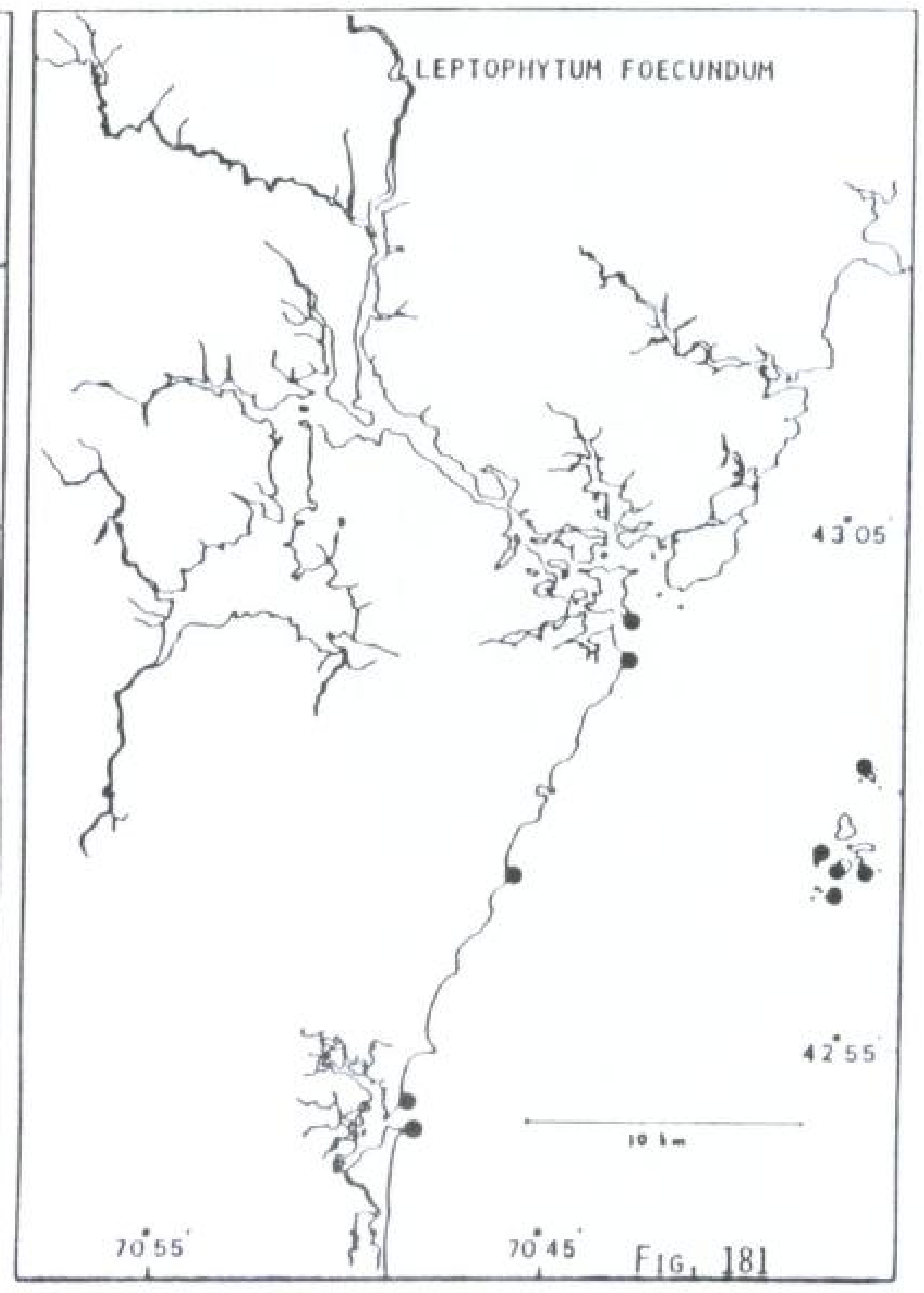


FIG. 181

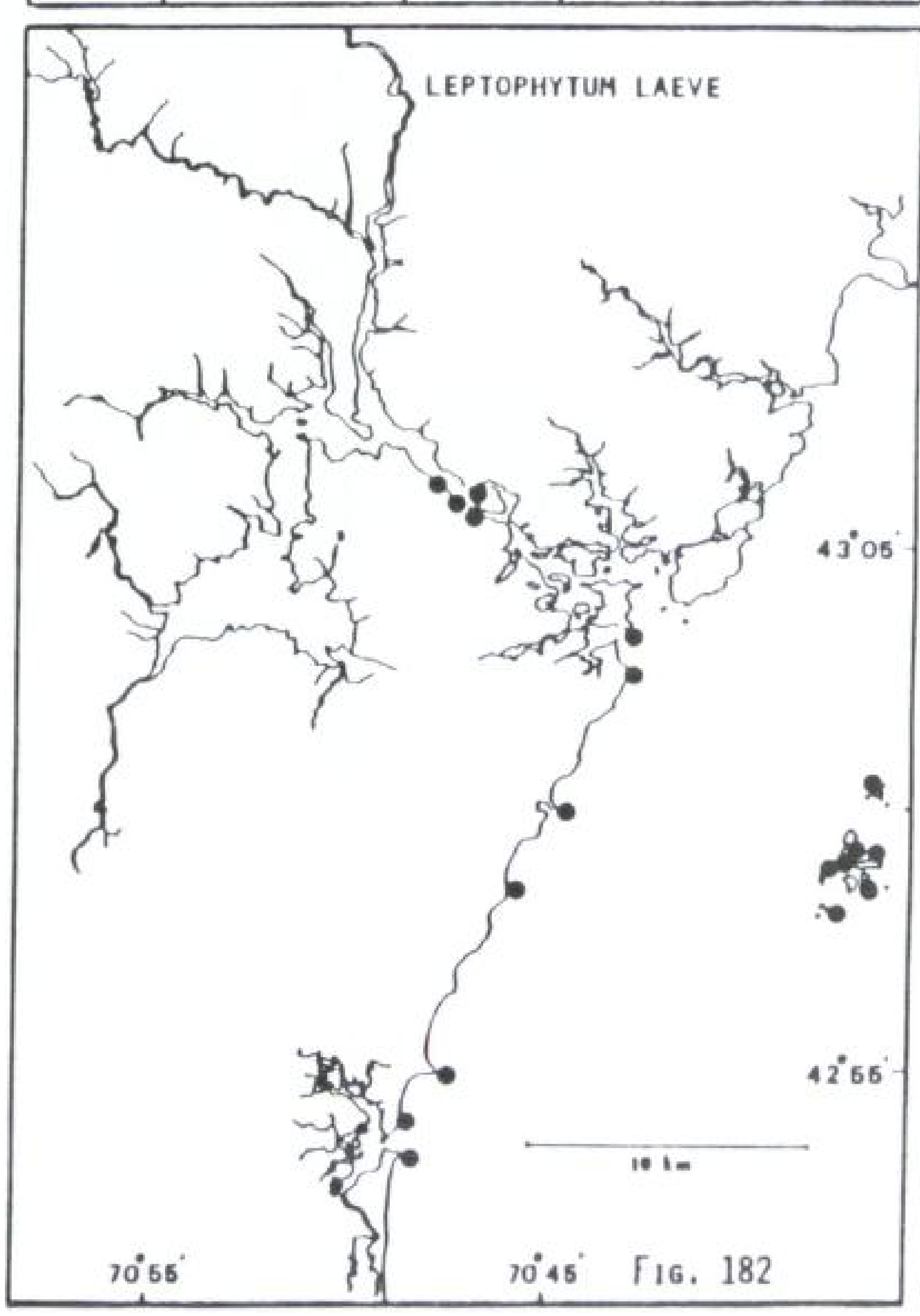


FIG. 182

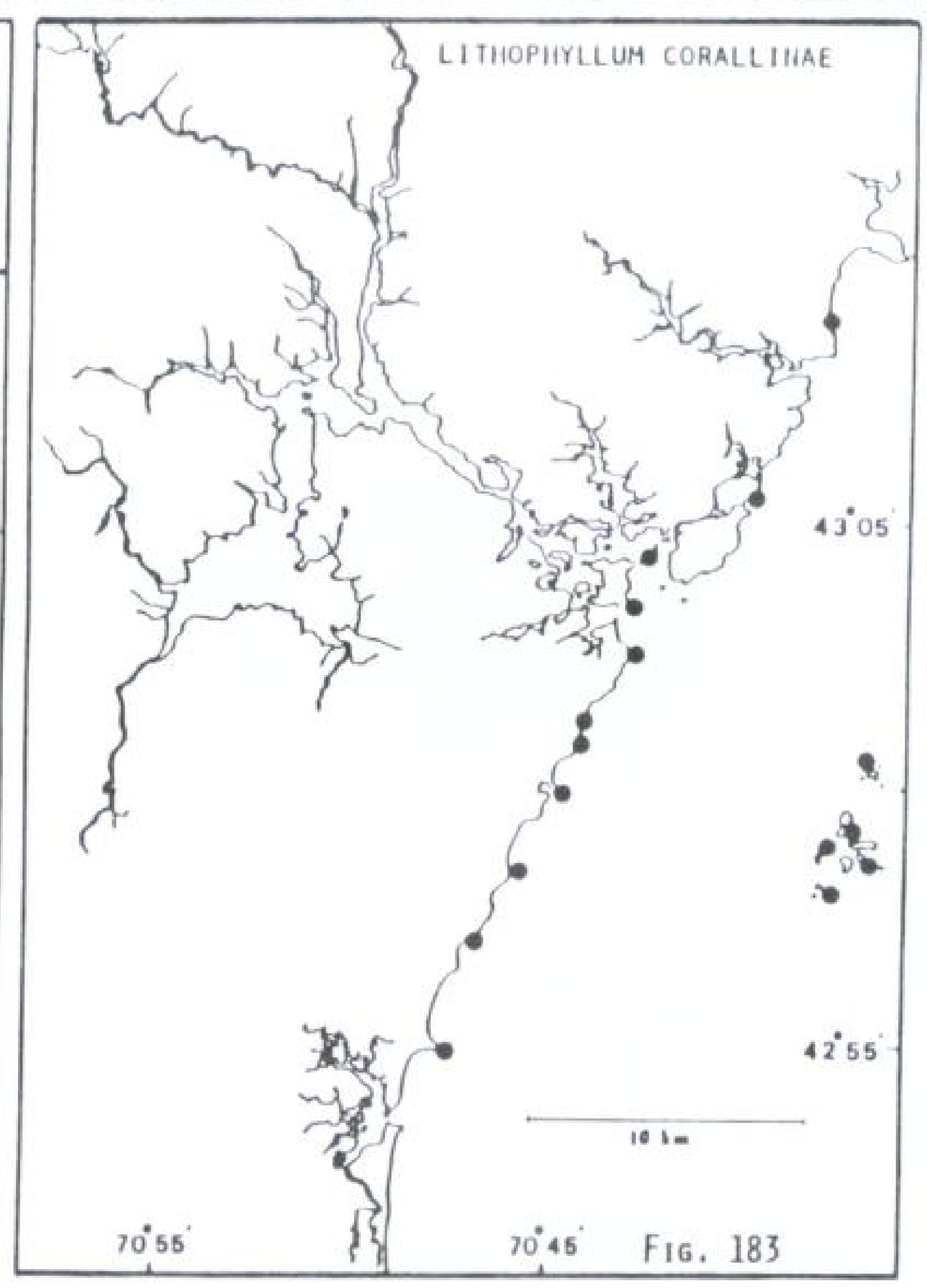


FIG. 183

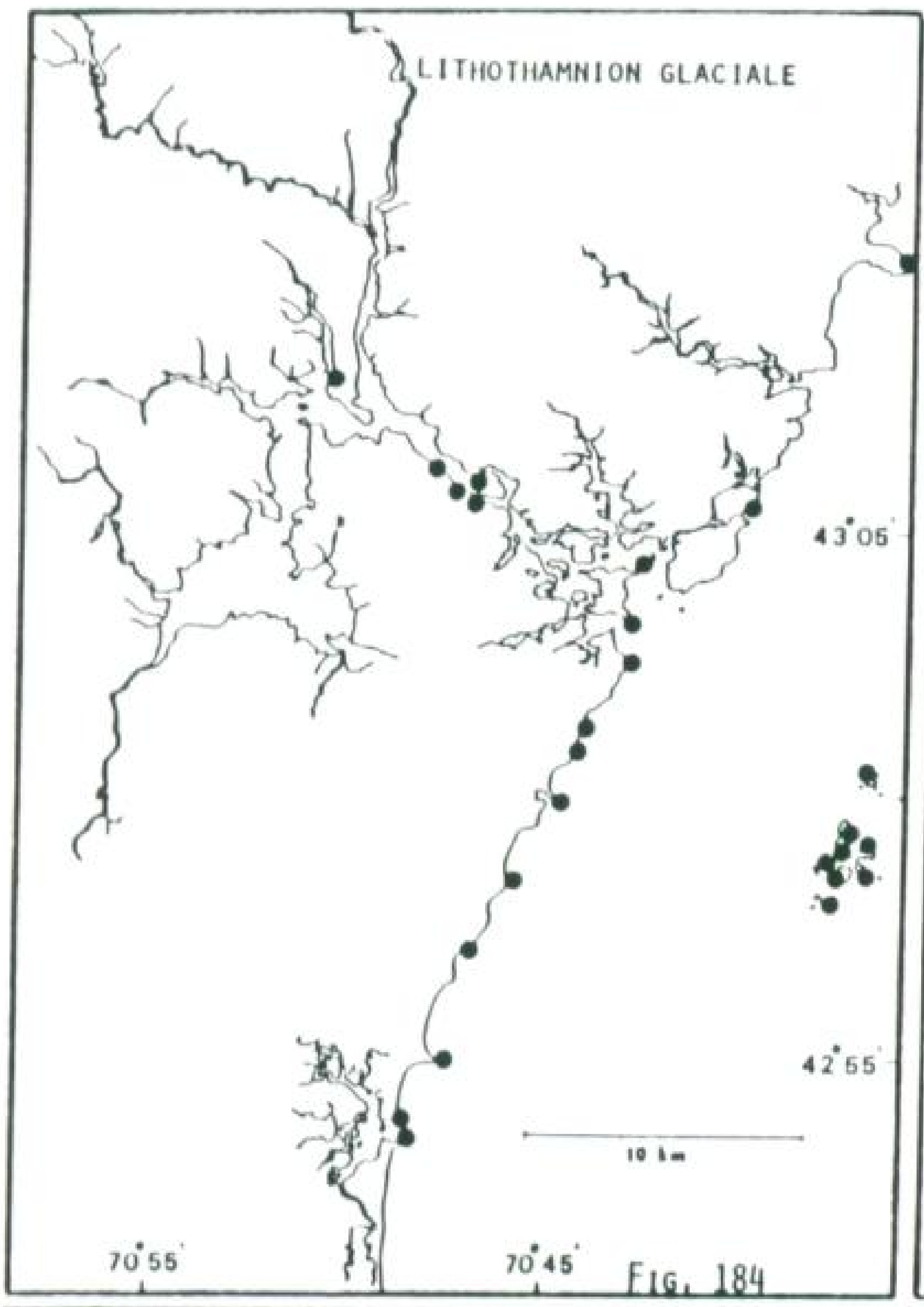


FIG. 184

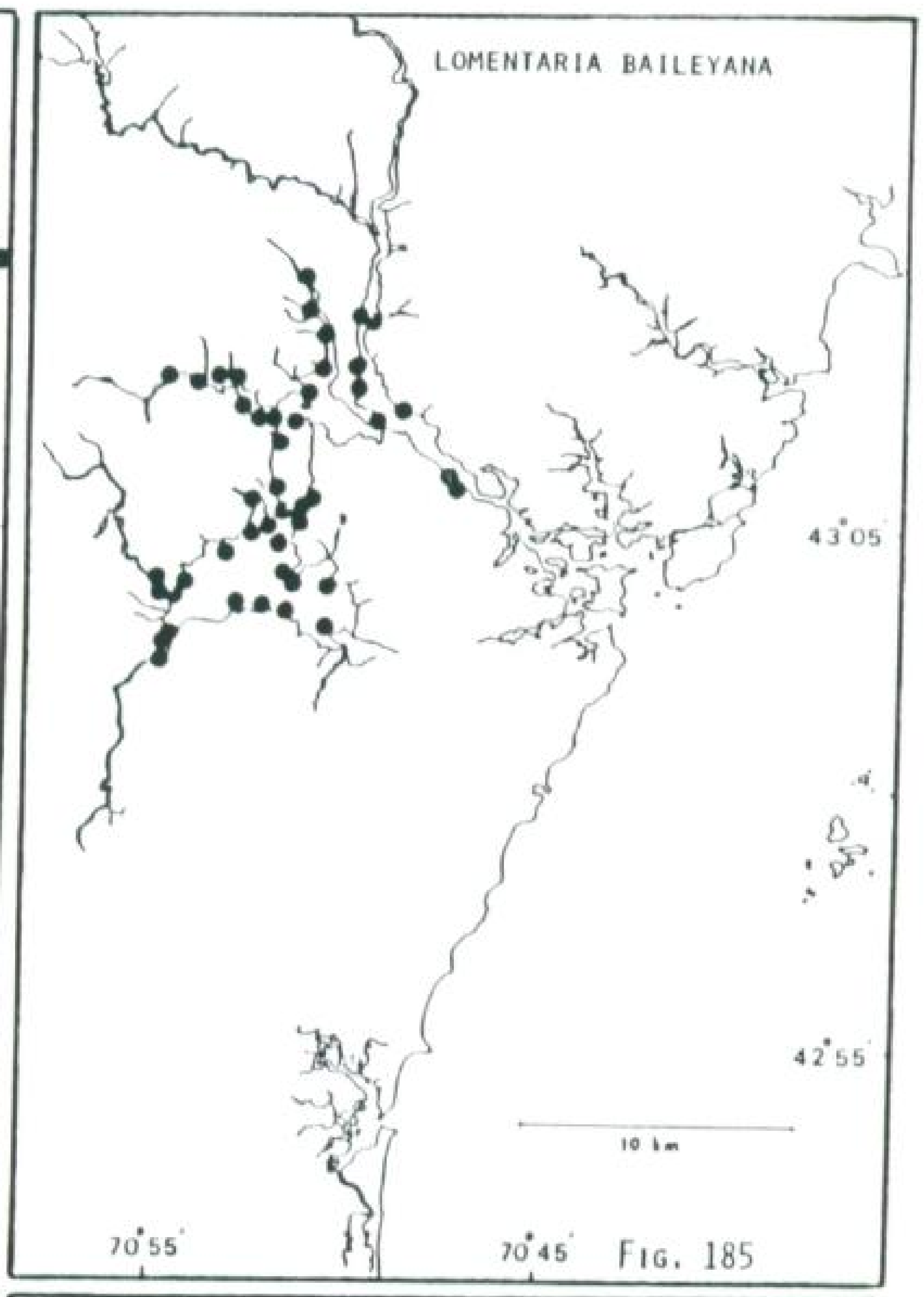


FIG. 185

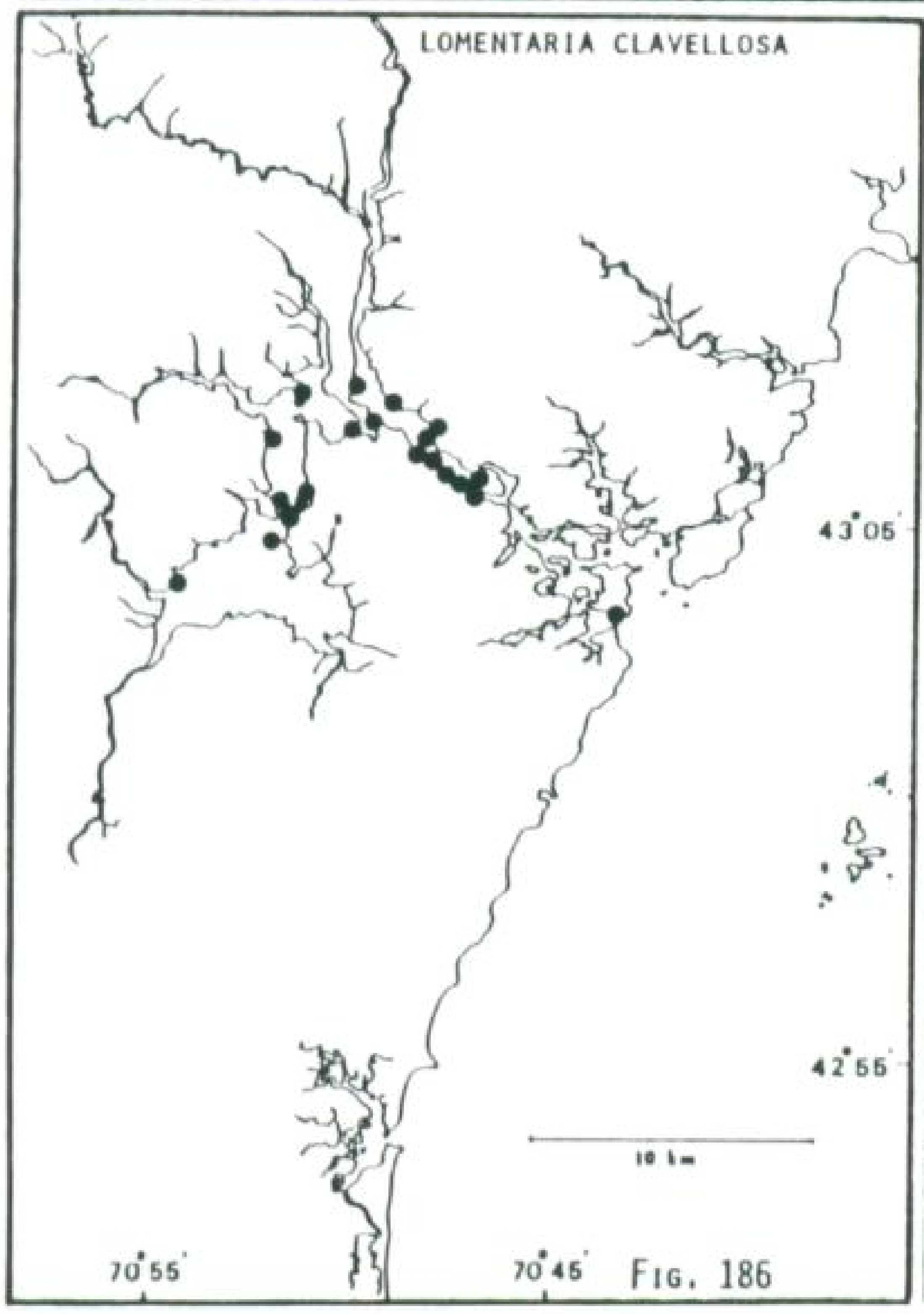


FIG. 186

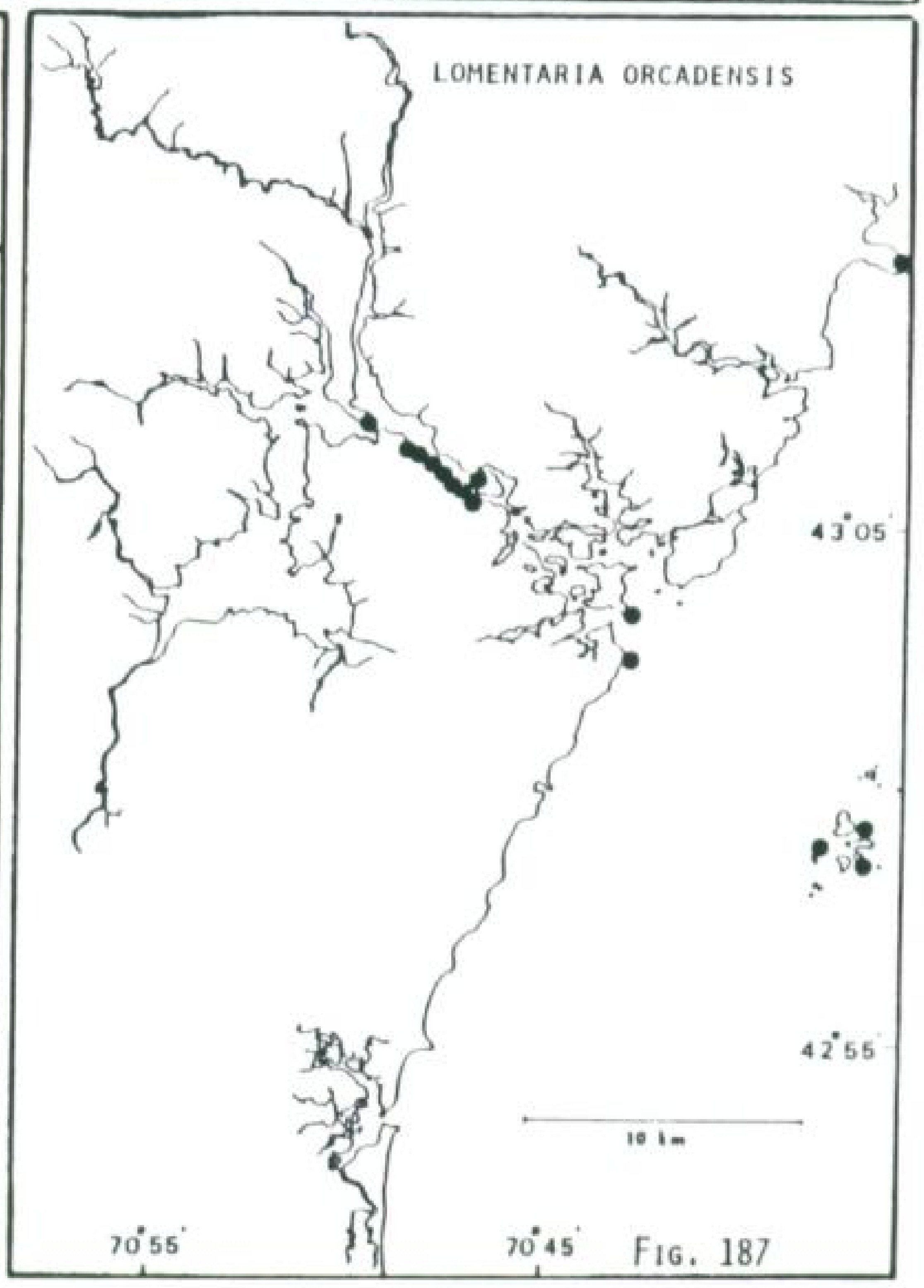


FIG. 187

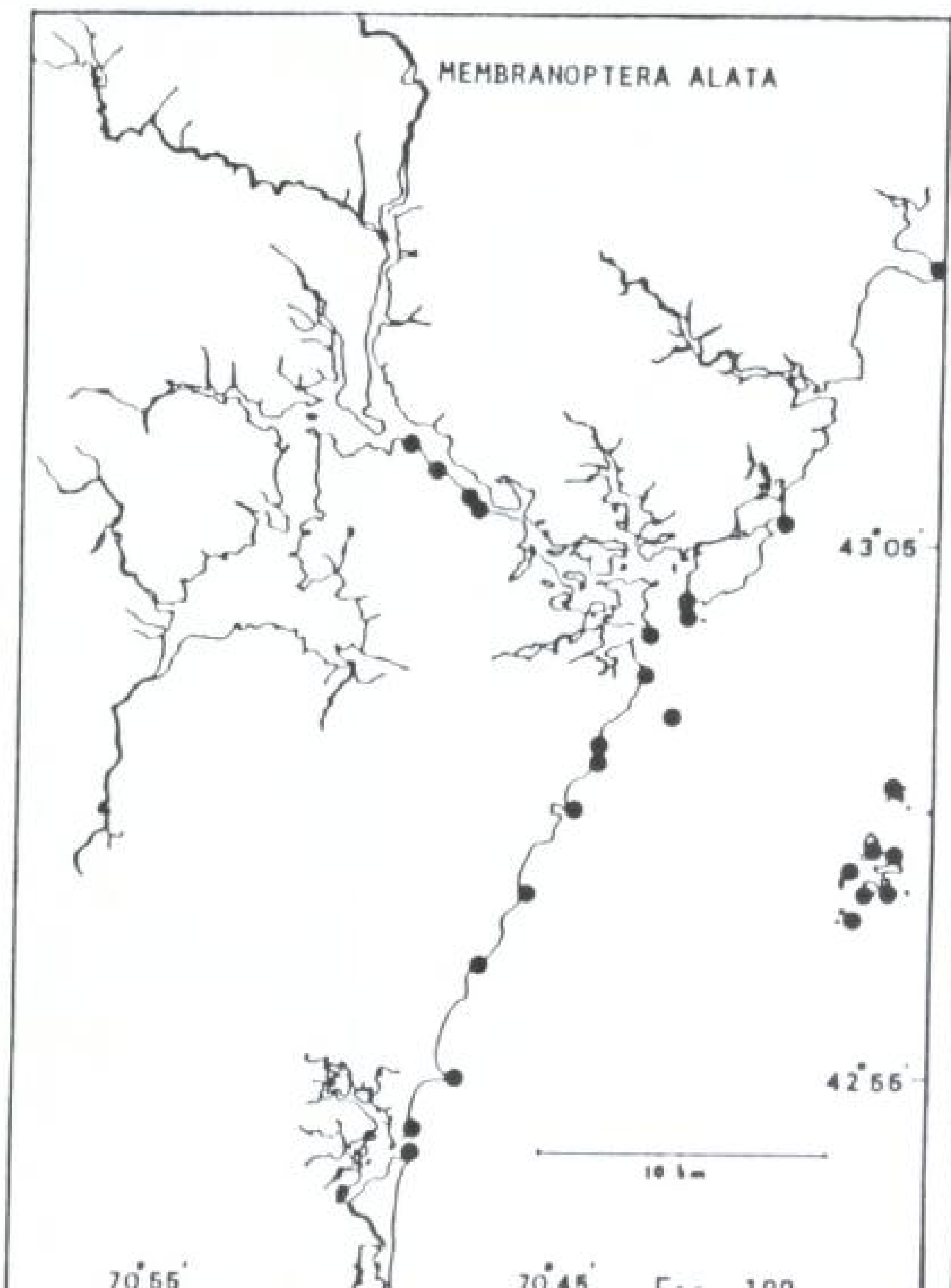


FIG. 188

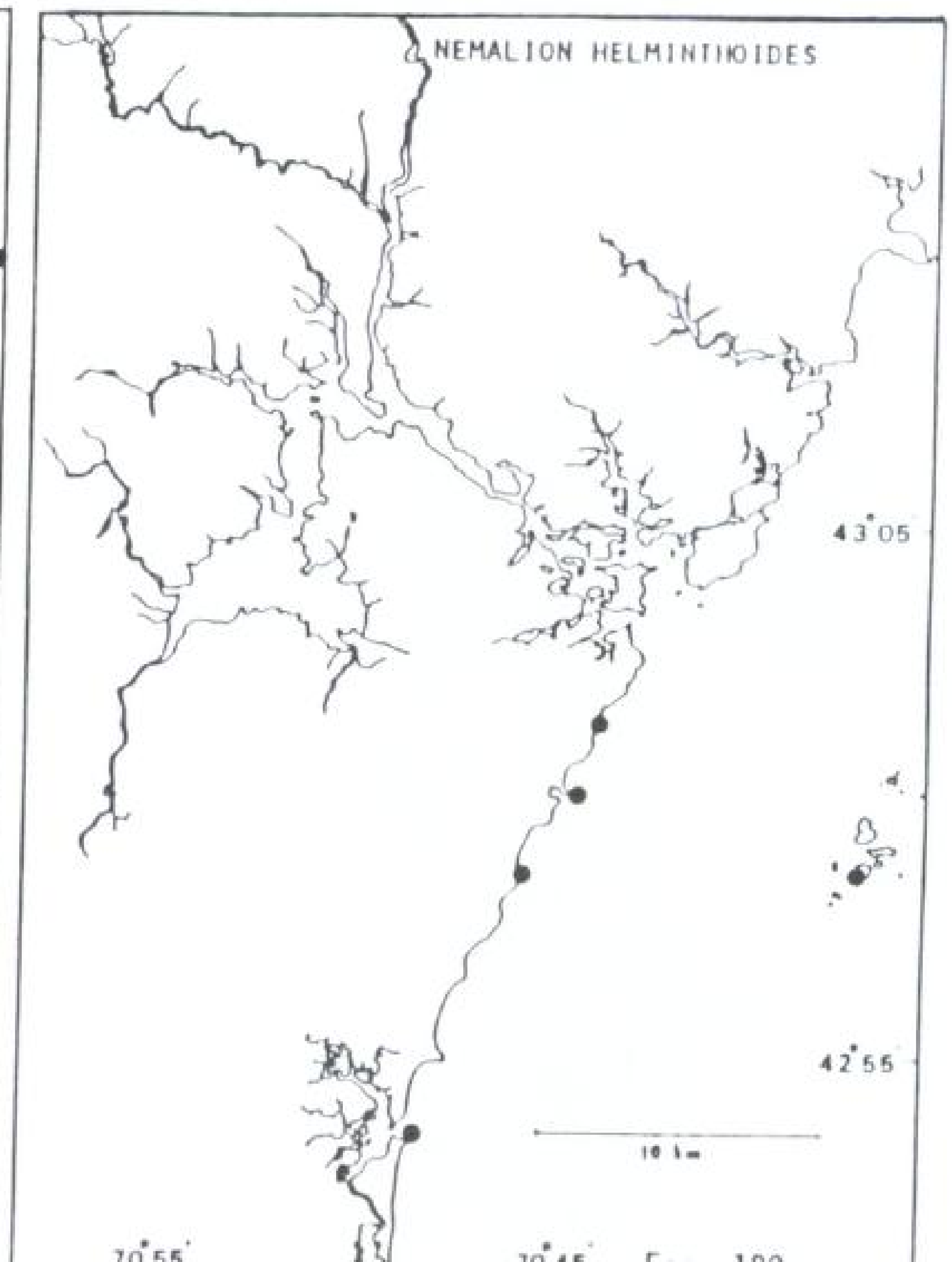


FIG. 189

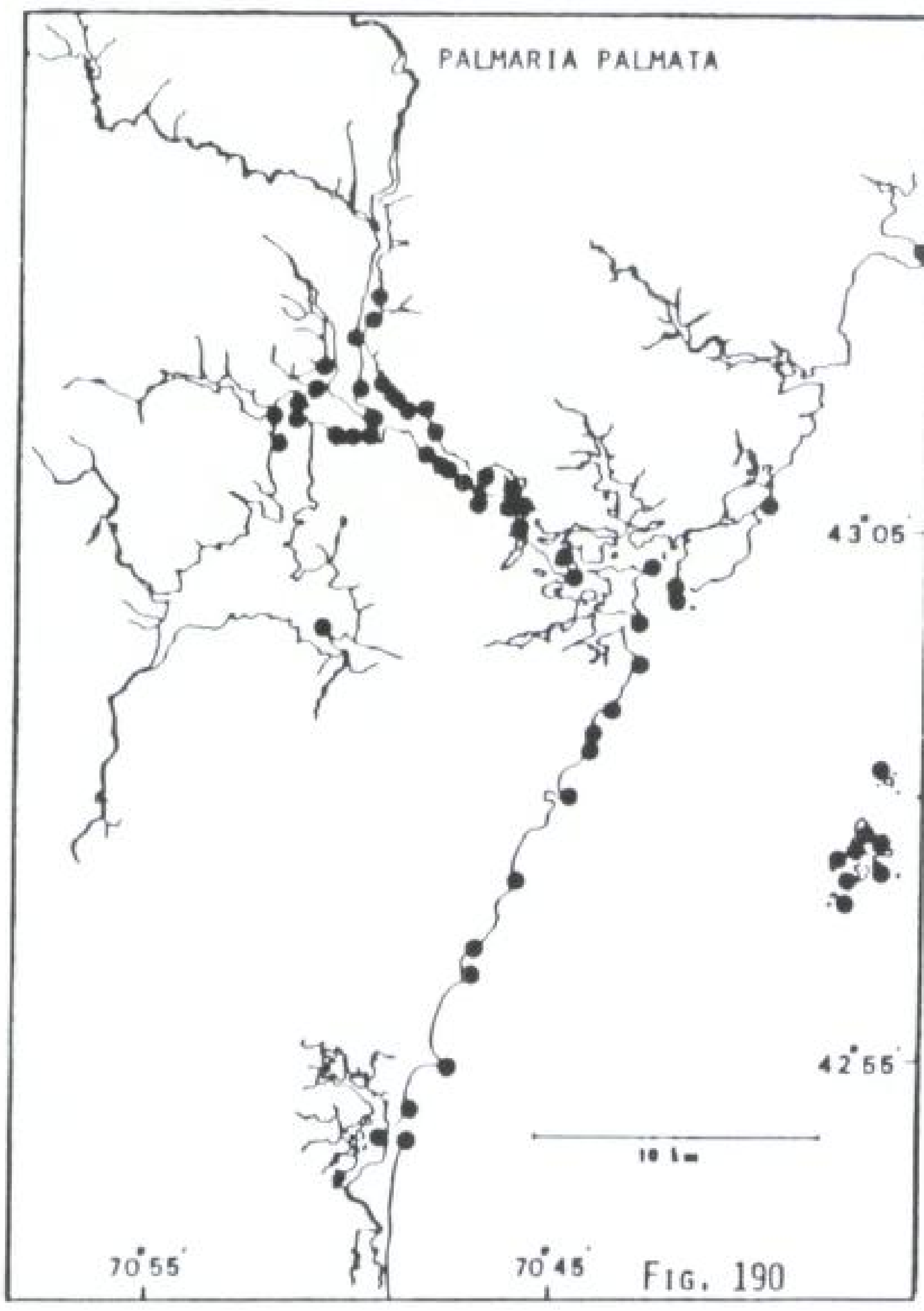


FIG. 190

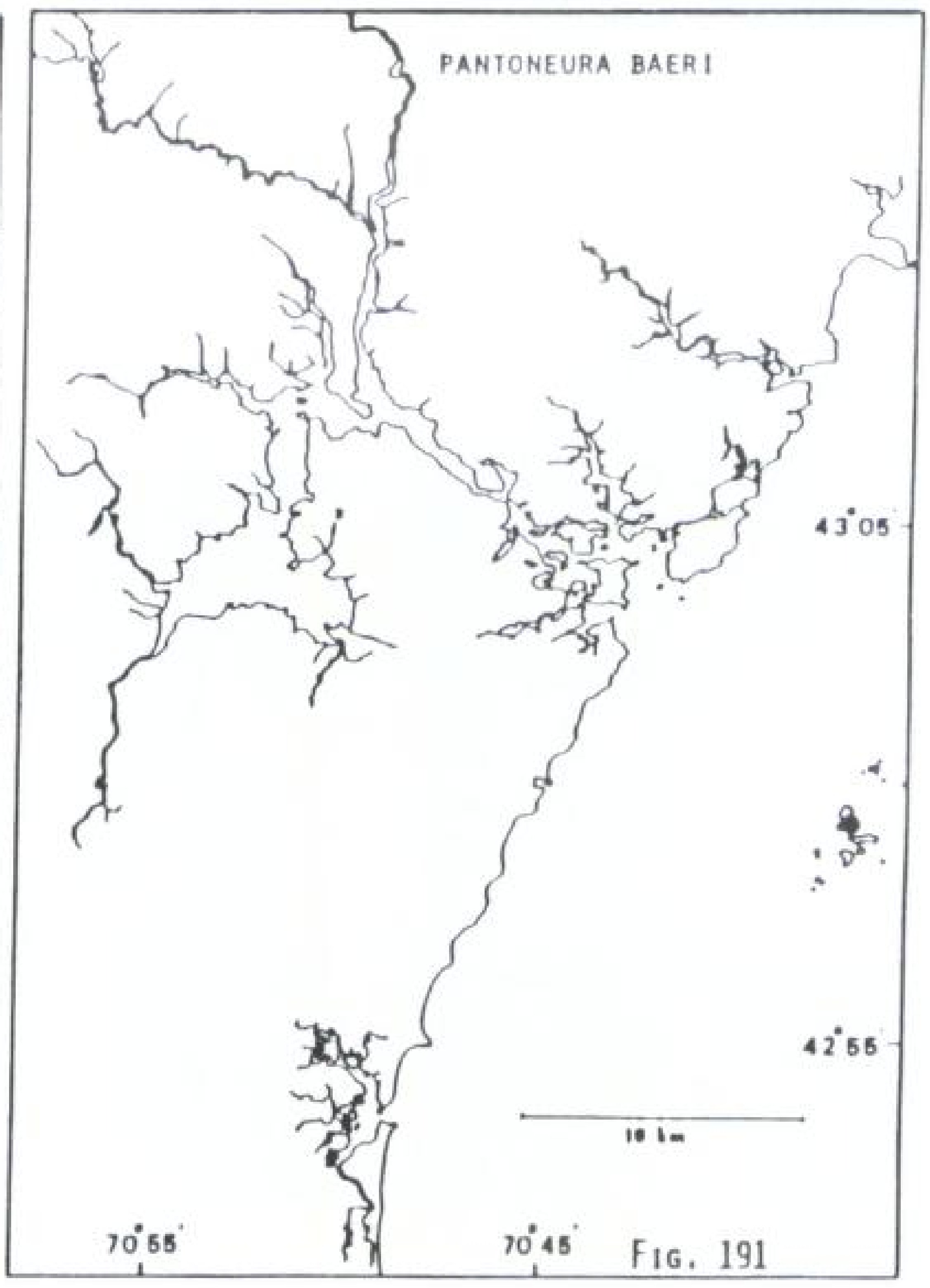


FIG. 191

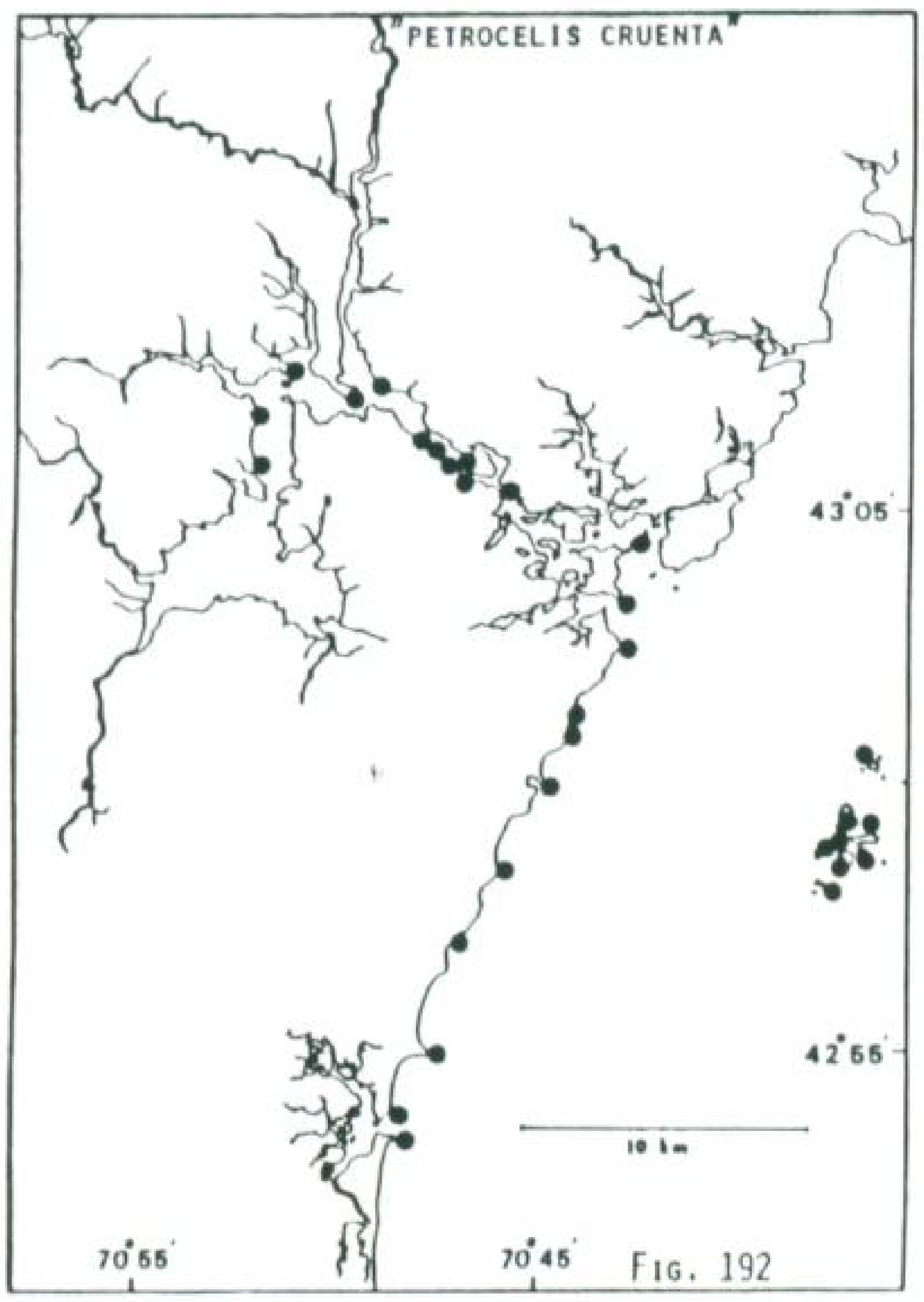


Fig. 192

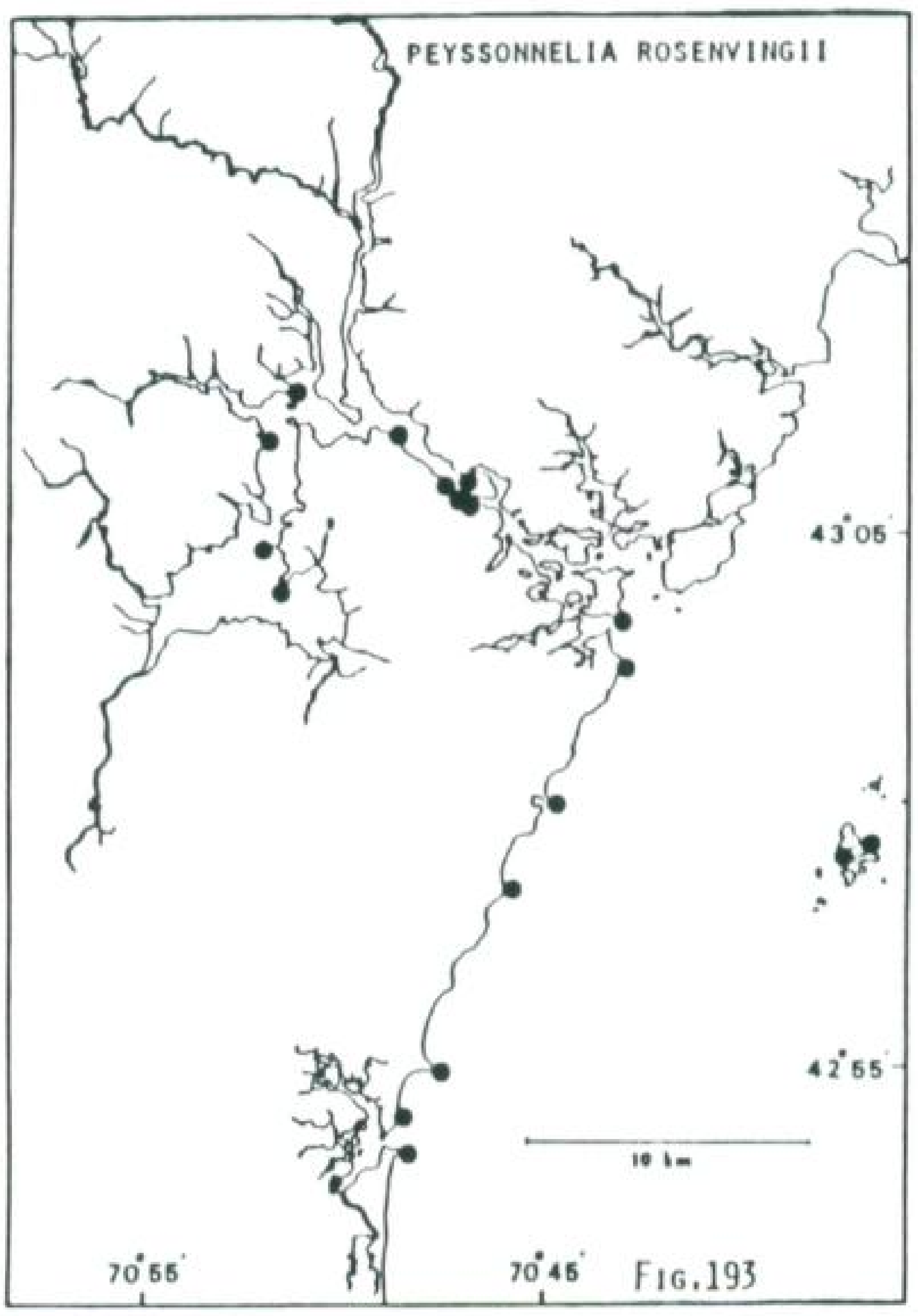


Fig. 193

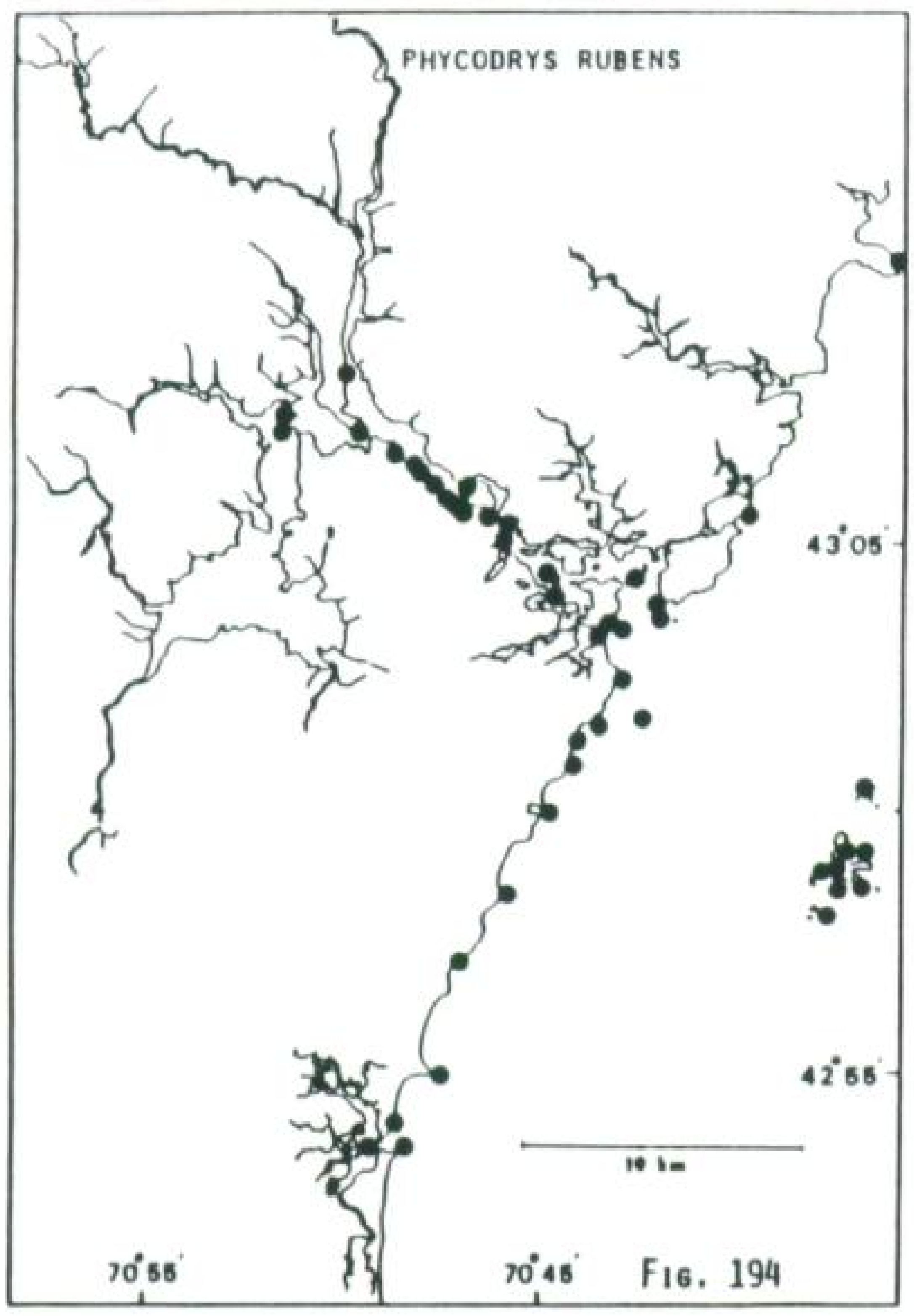


Fig. 194

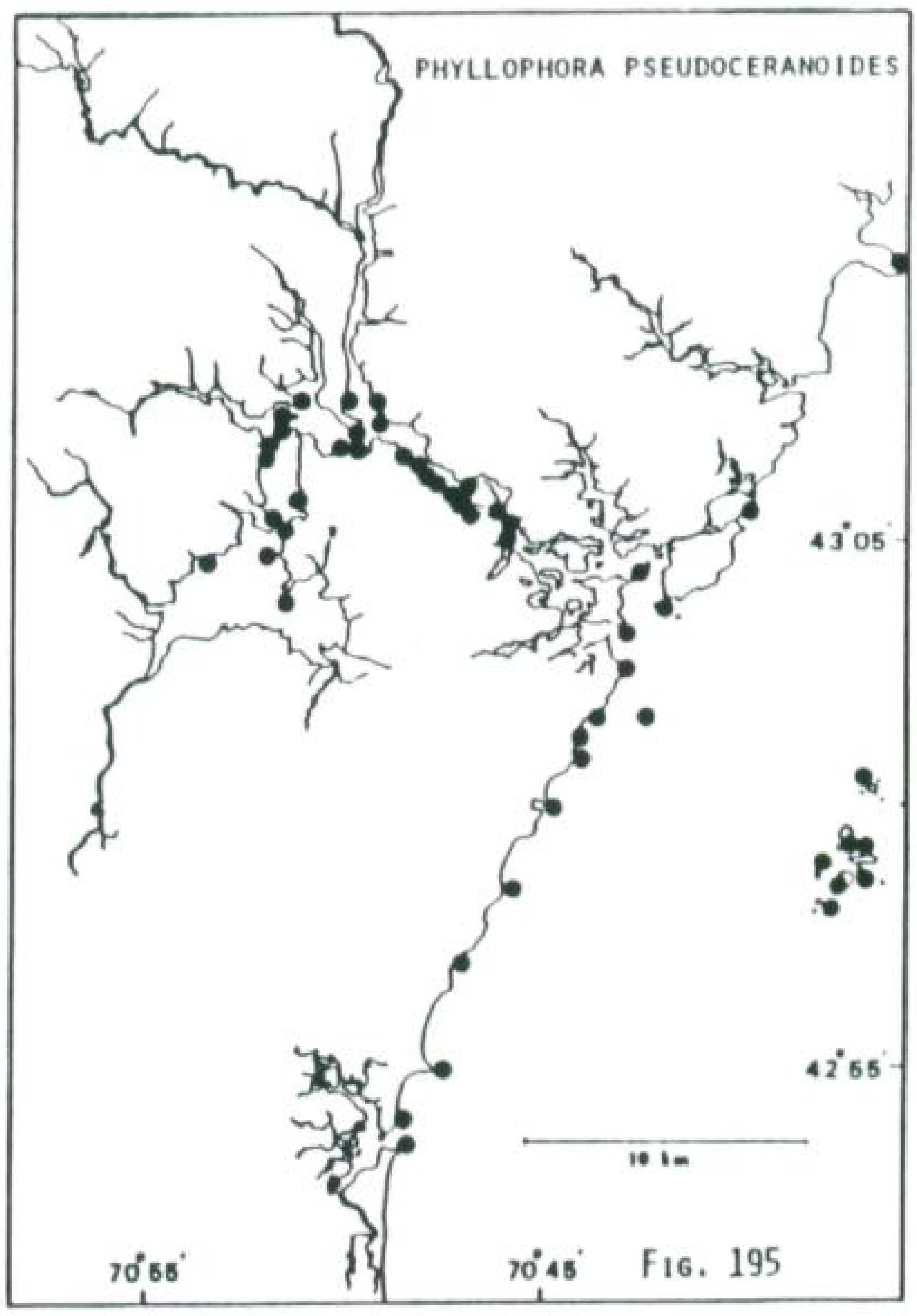


Fig. 195

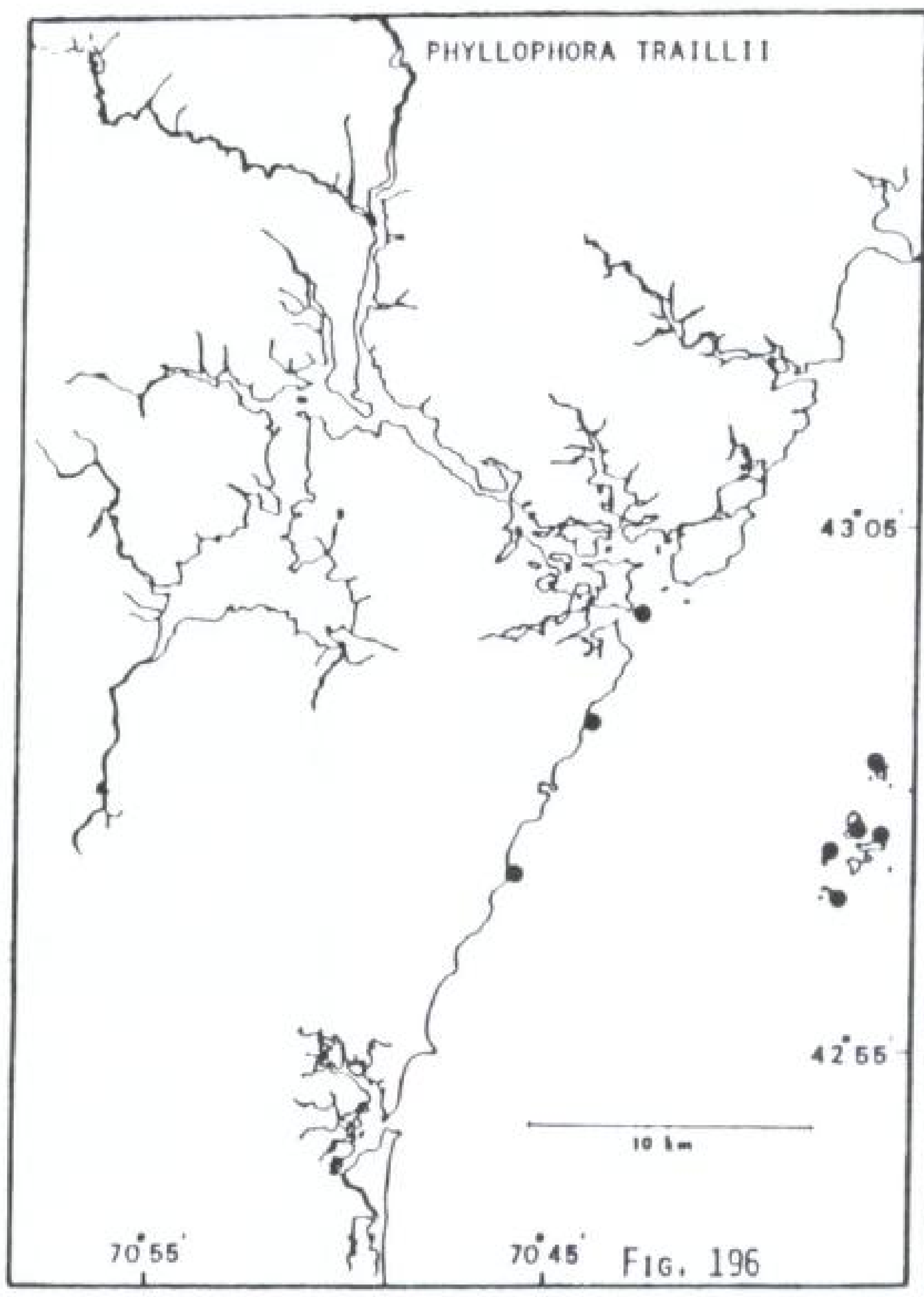


FIG. 196

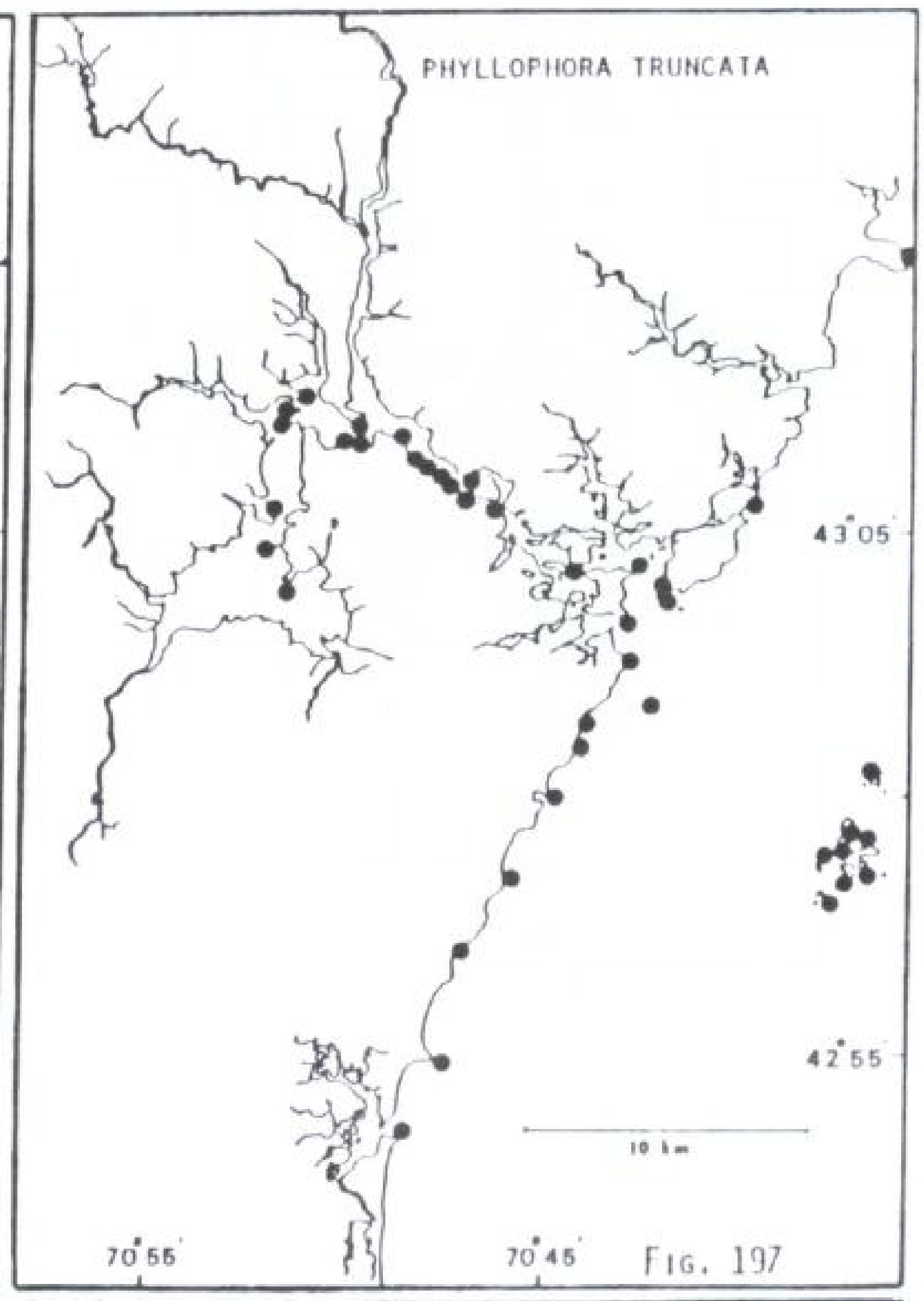


FIG. 197

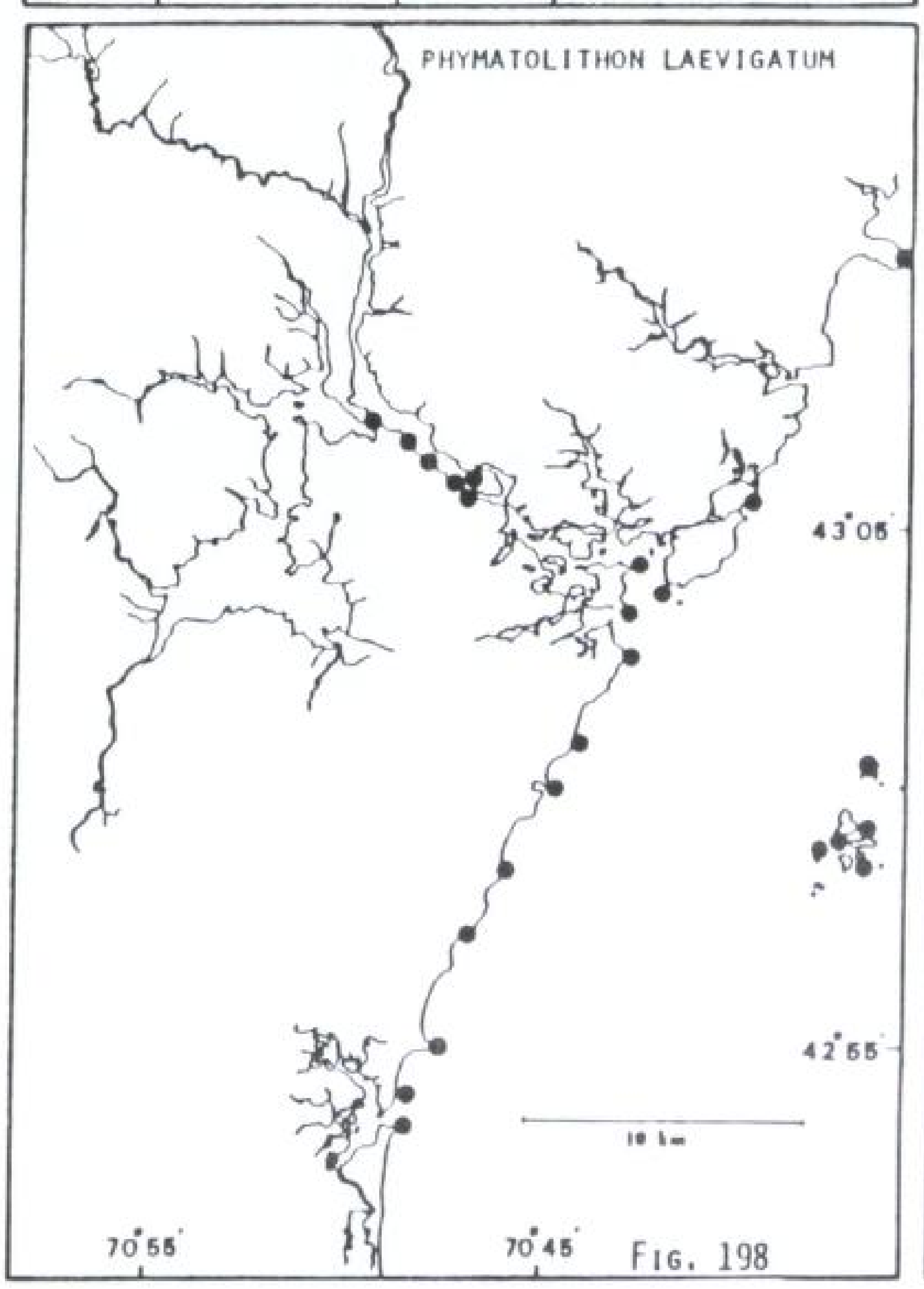


FIG. 198

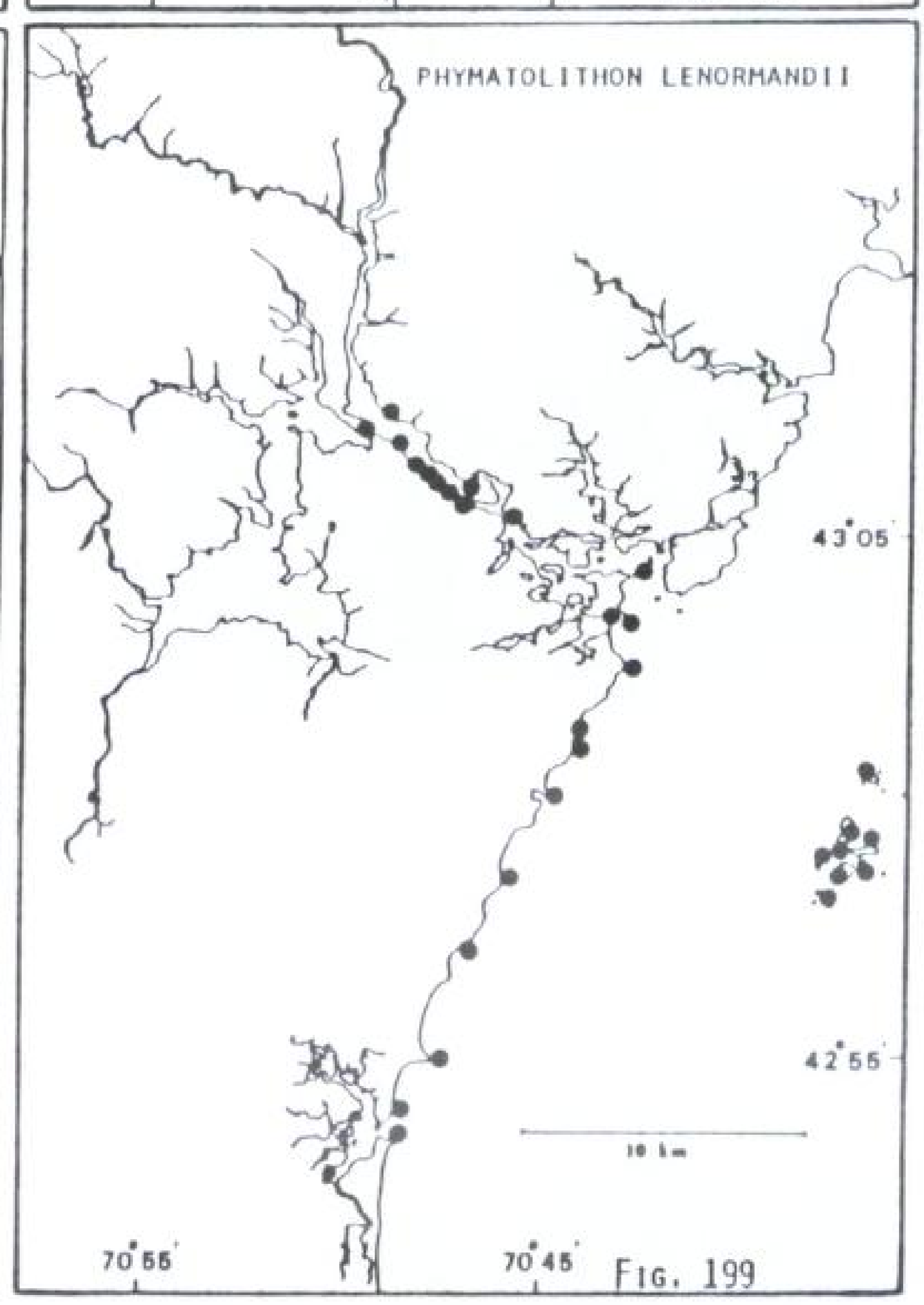


FIG. 199

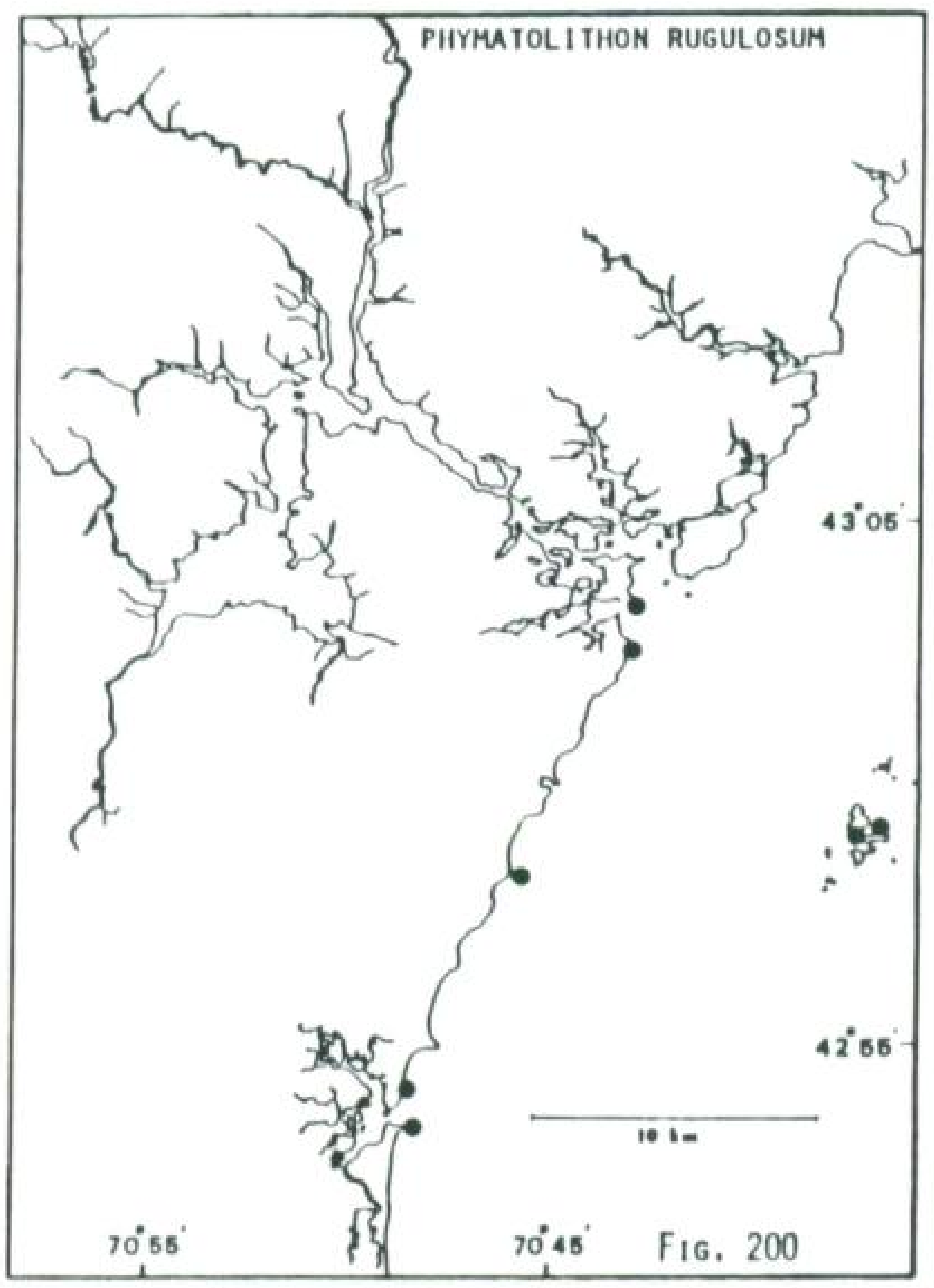


FIG. 200

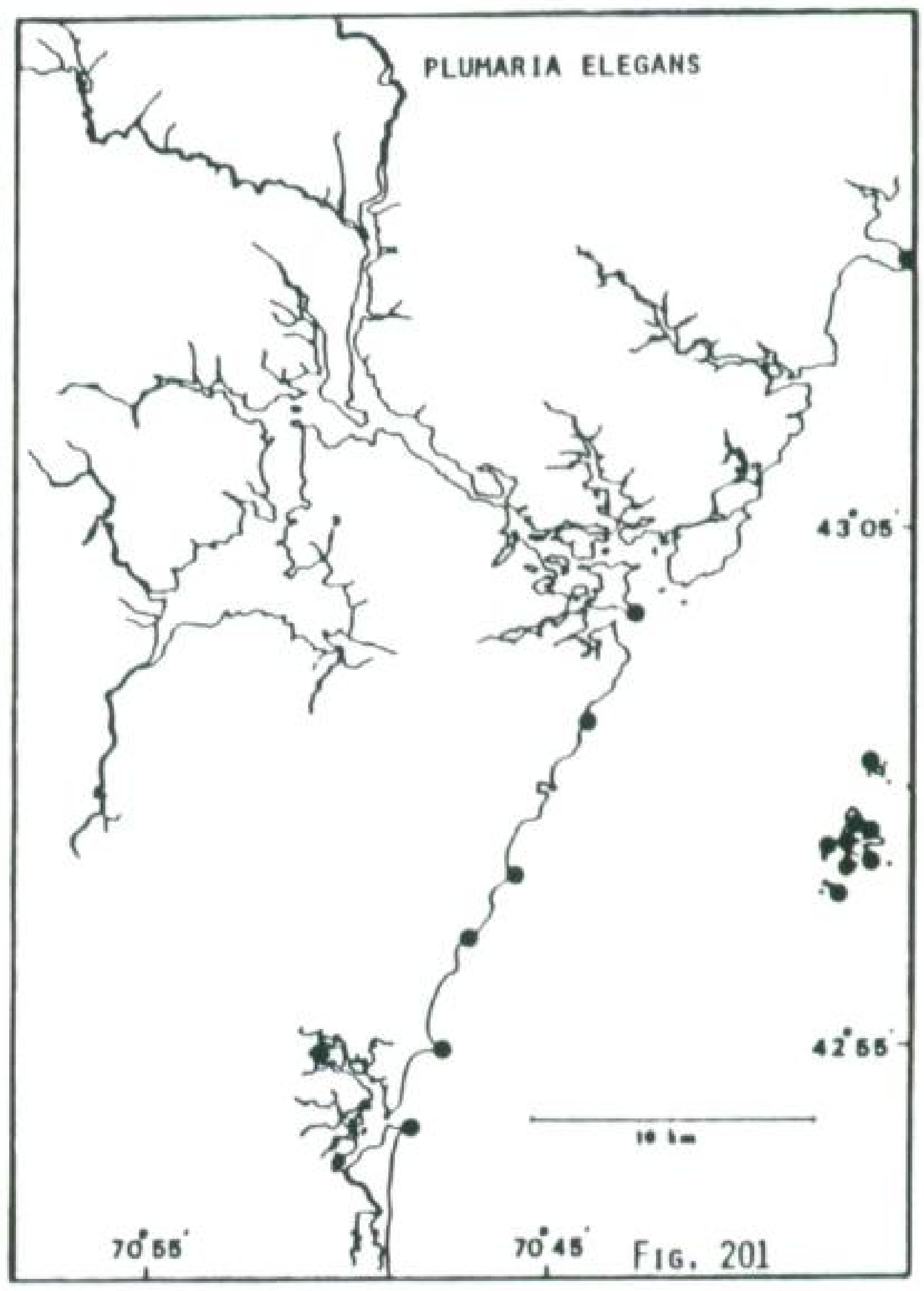


FIG. 201

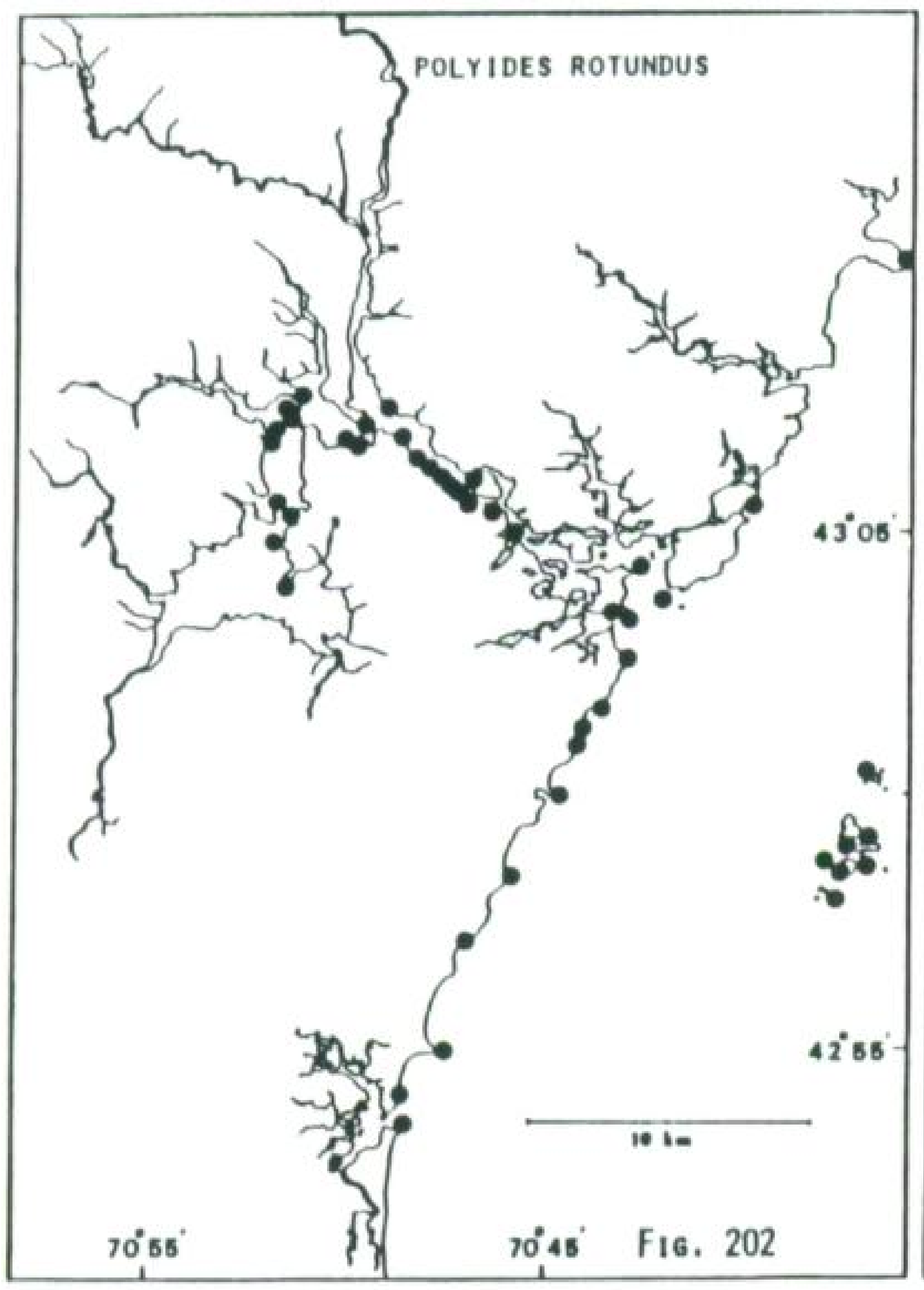


FIG. 202

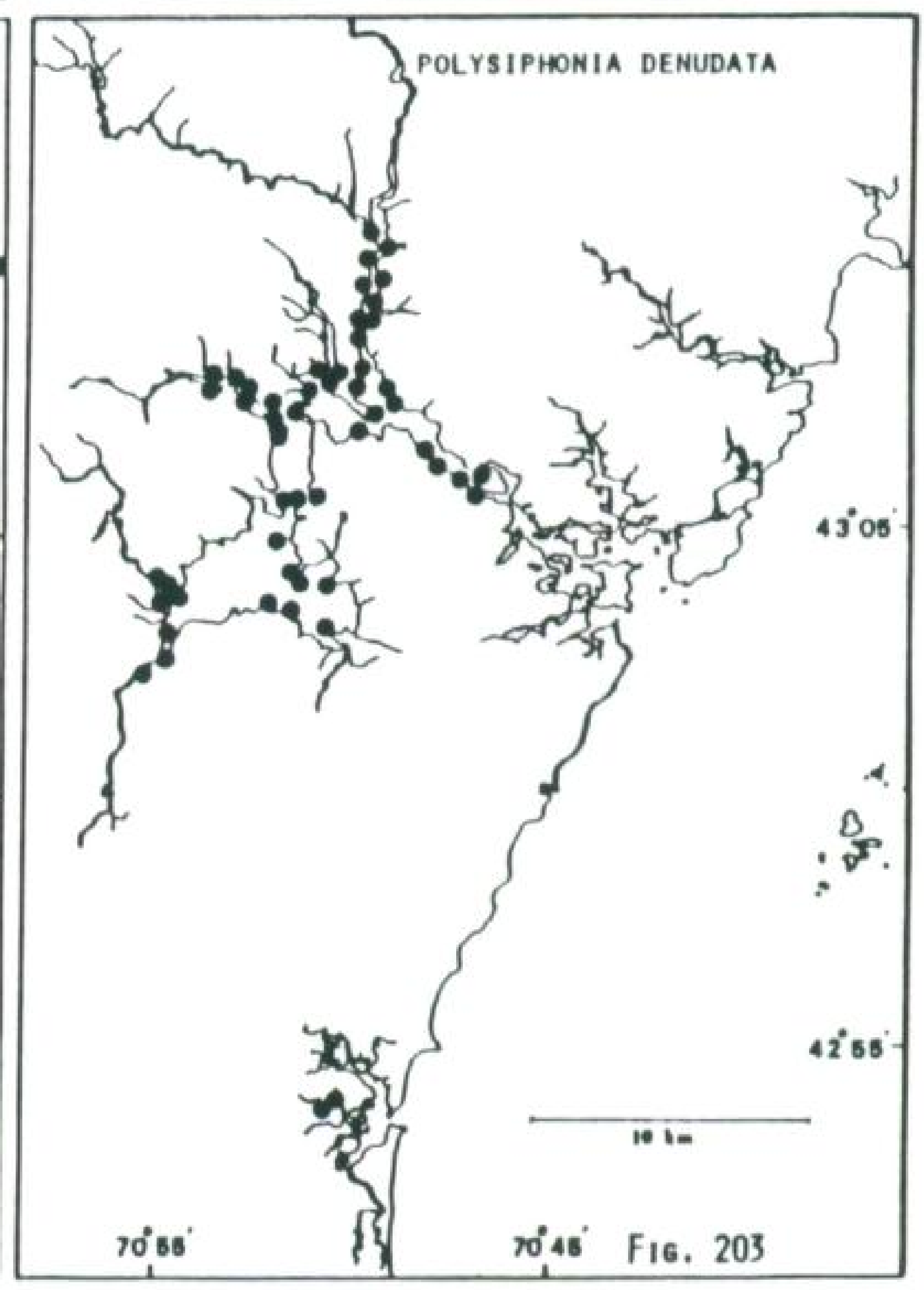


FIG. 203

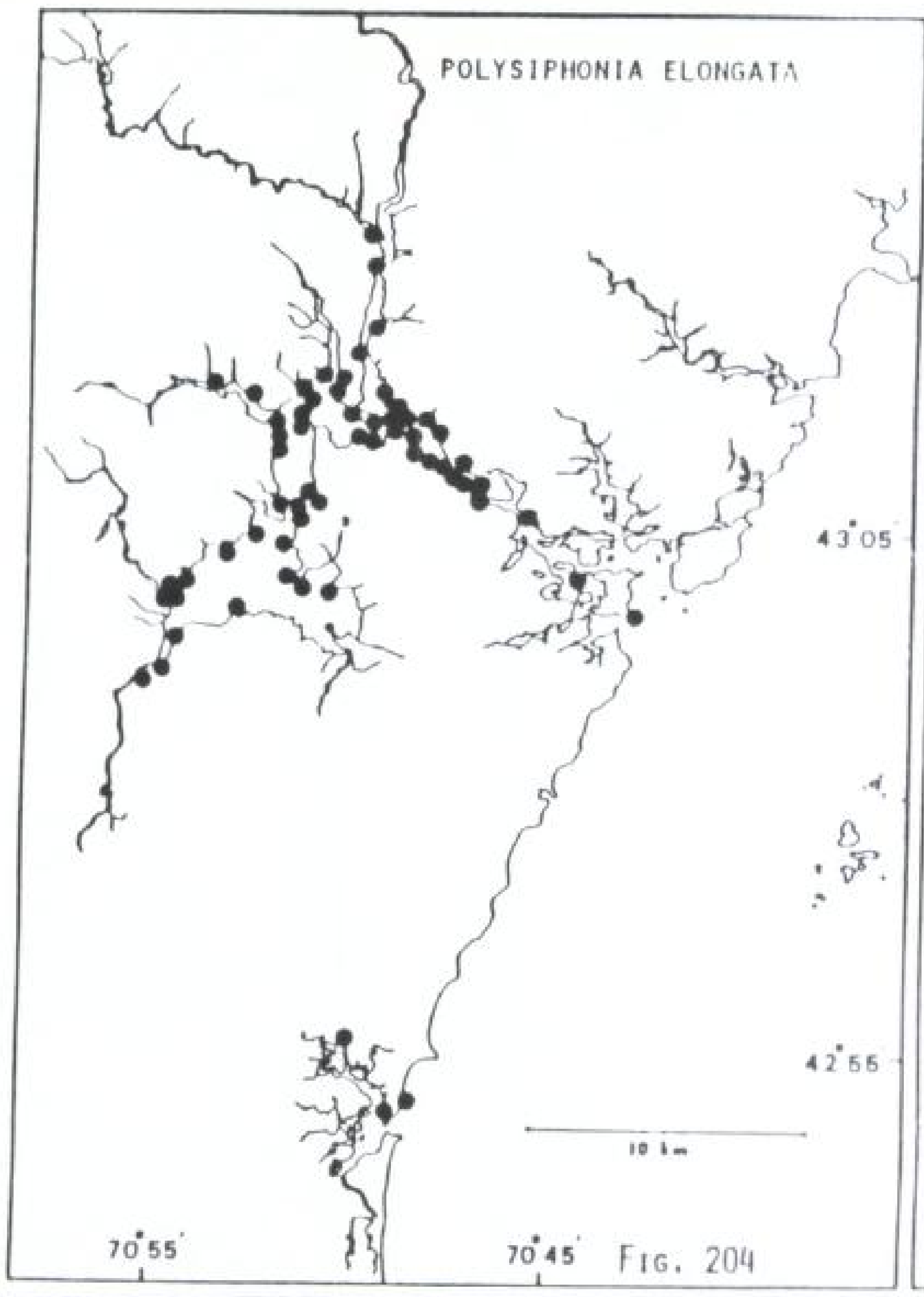


Fig. 204

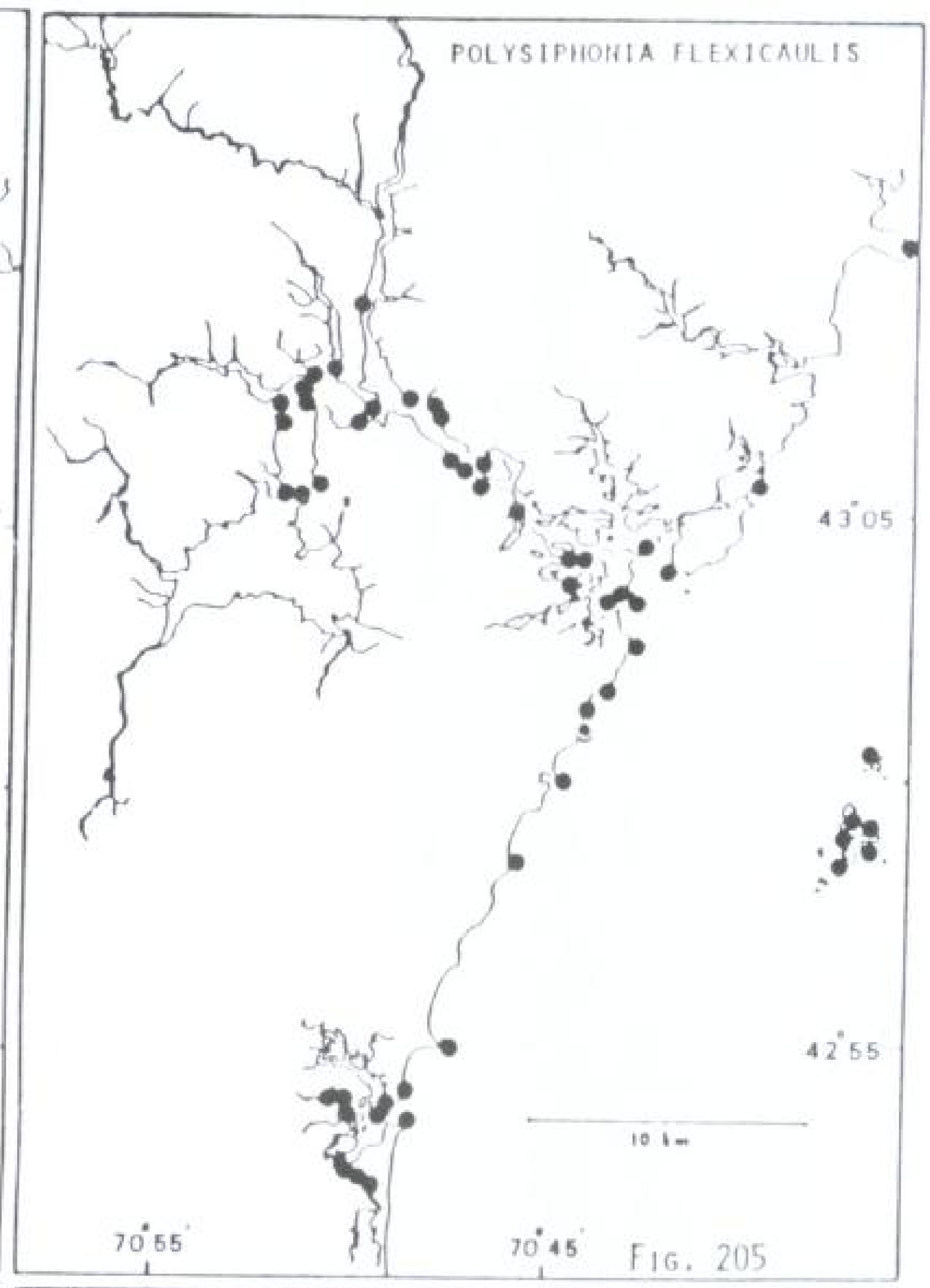


Fig. 205

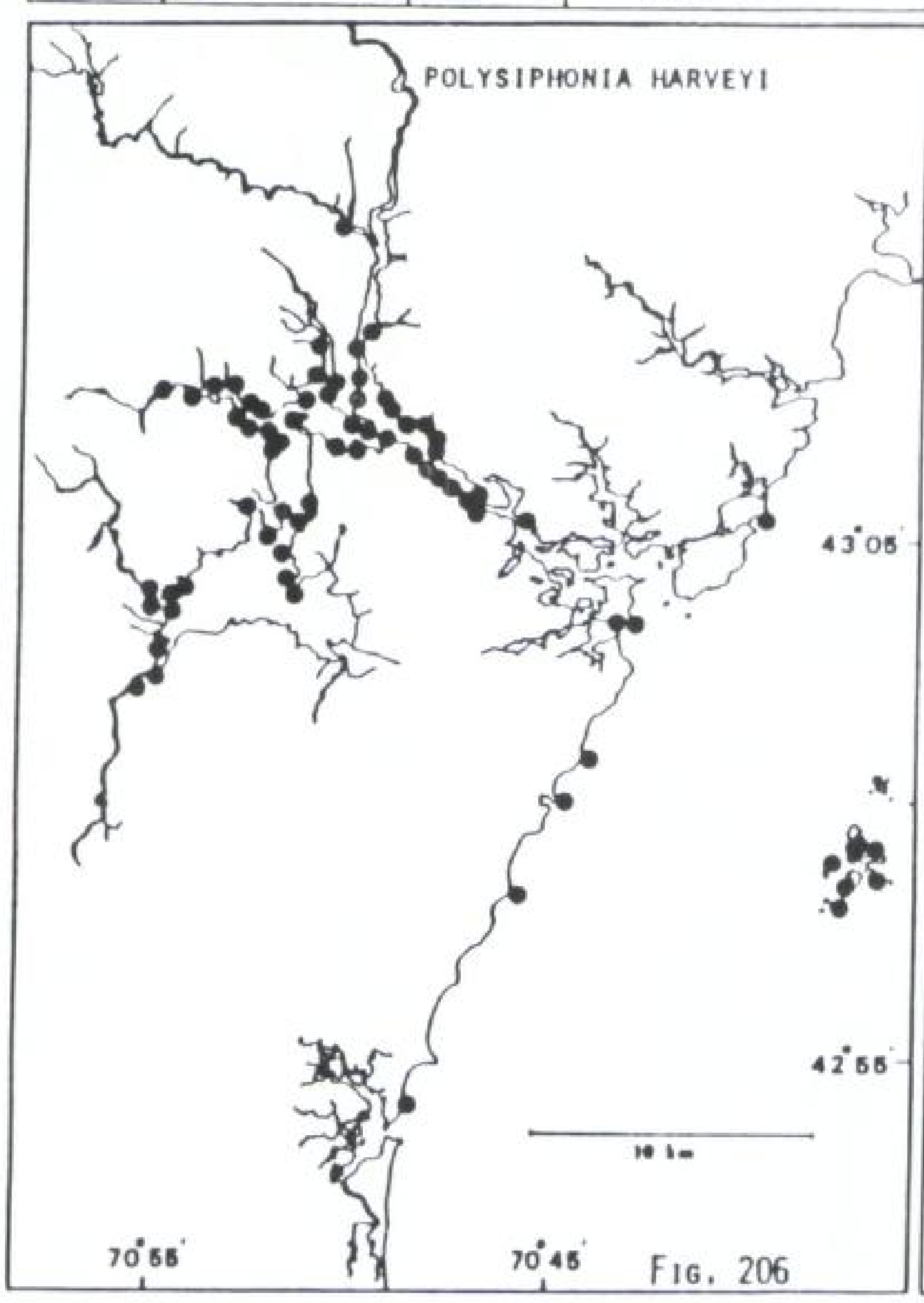


Fig. 206

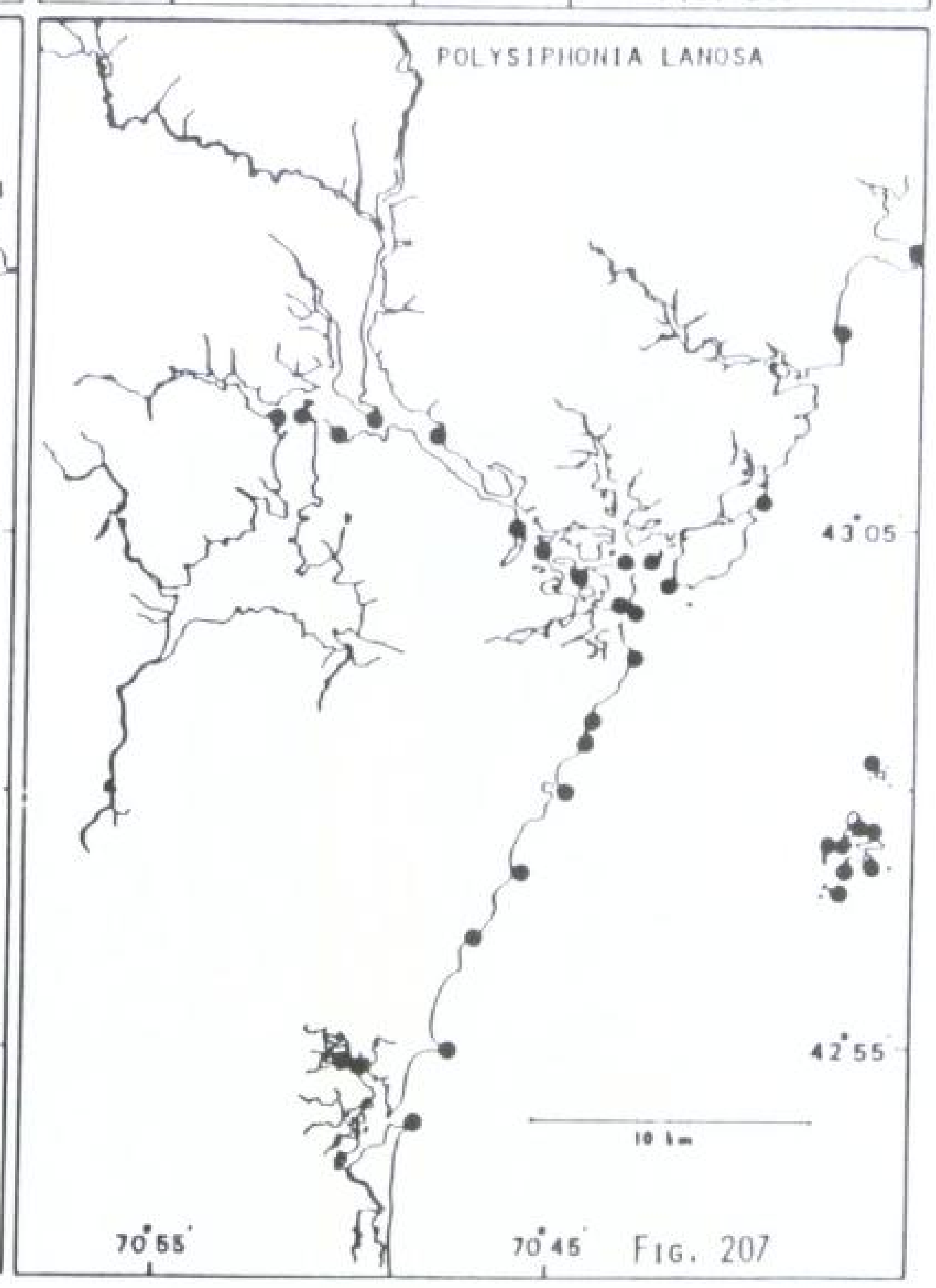


Fig. 207

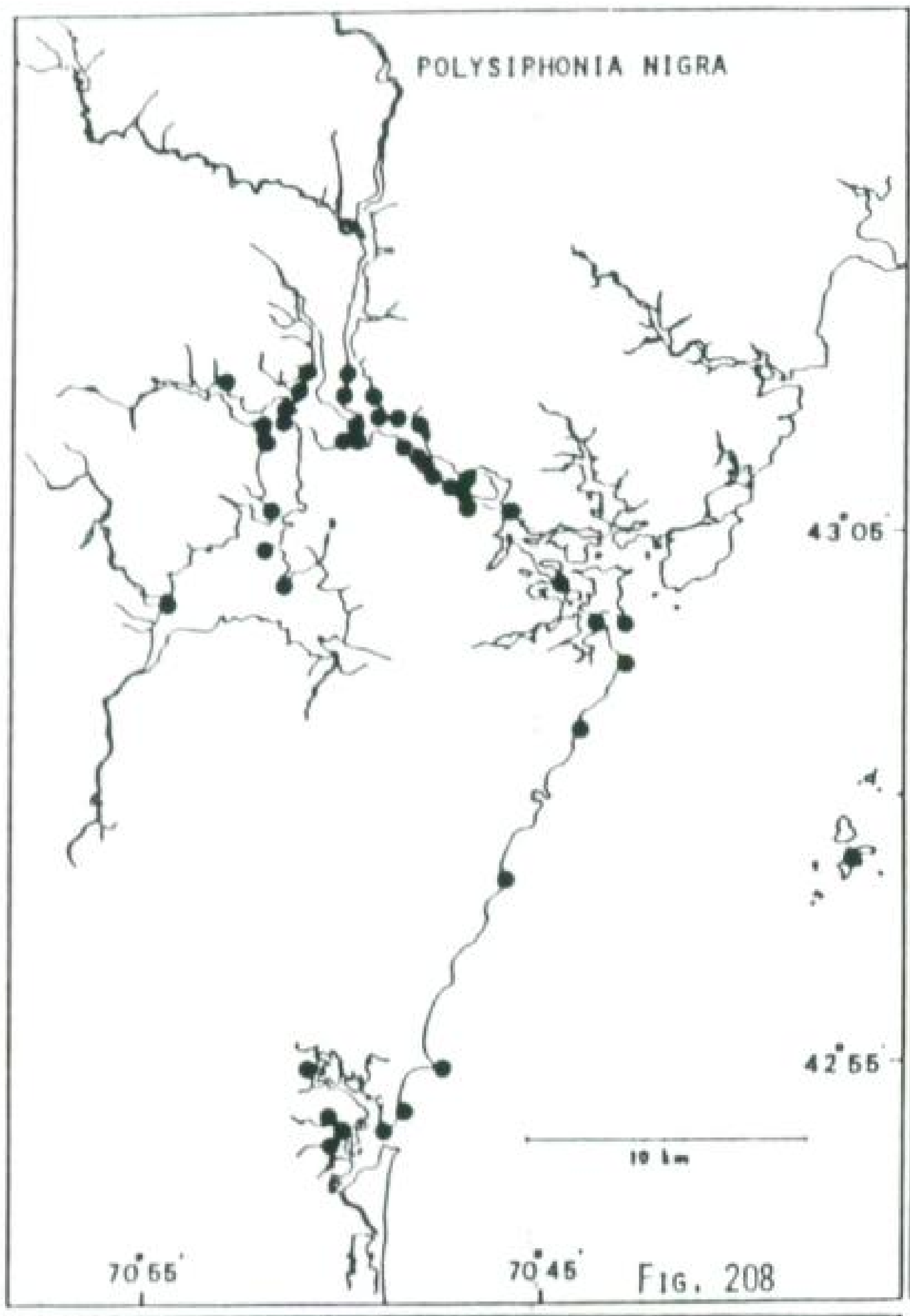


Fig. 208

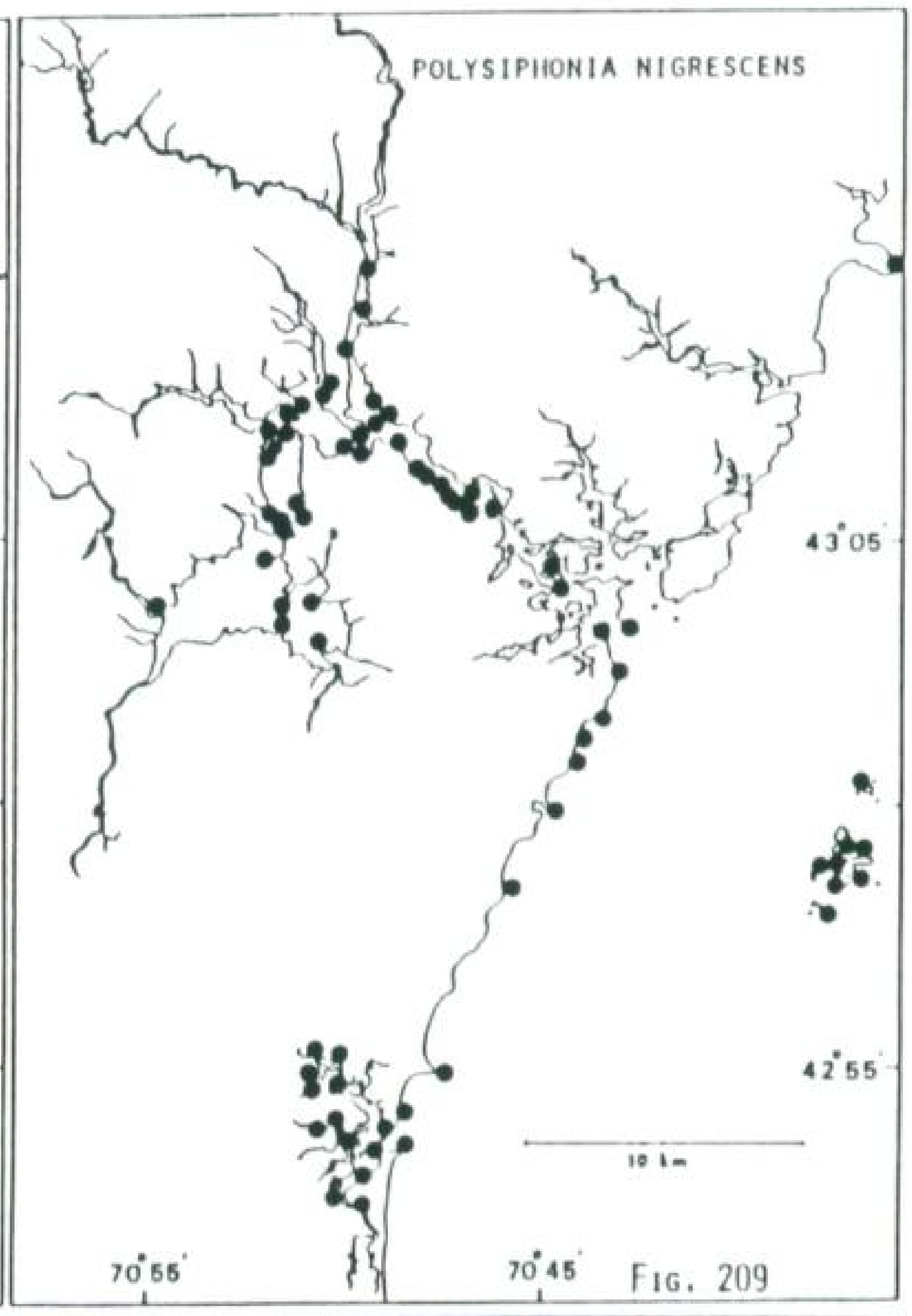
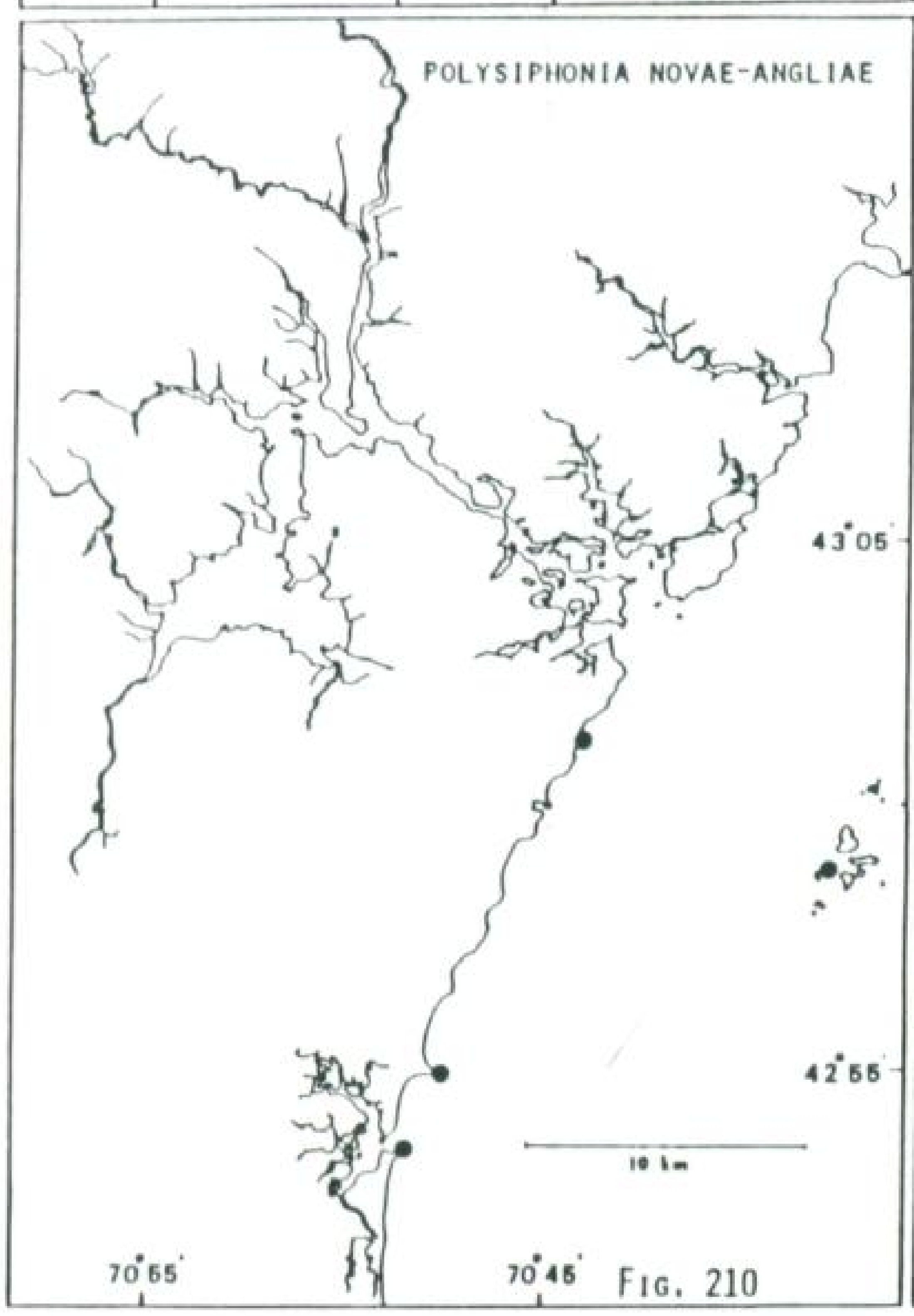


Fig. 209



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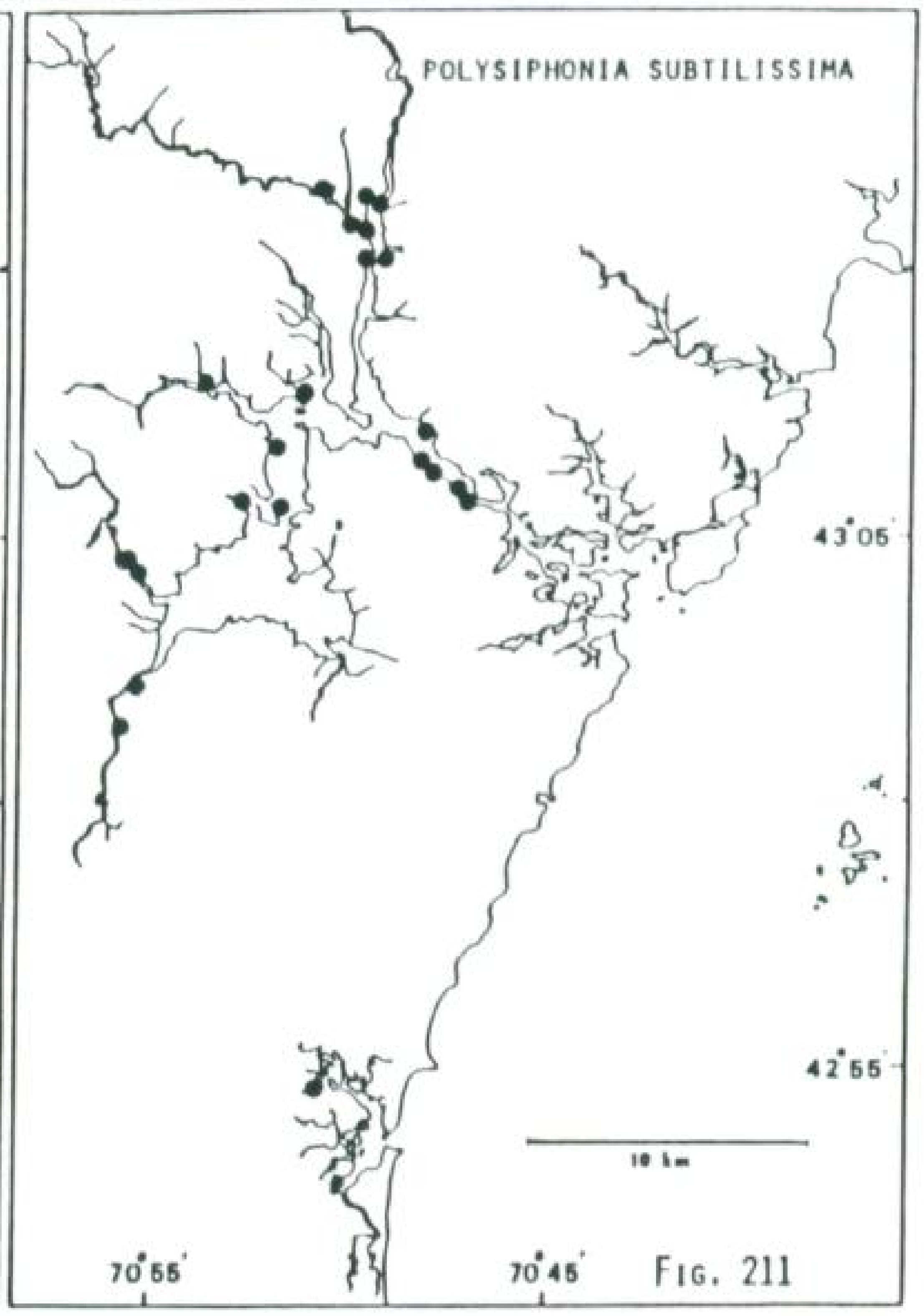


Fig. 211

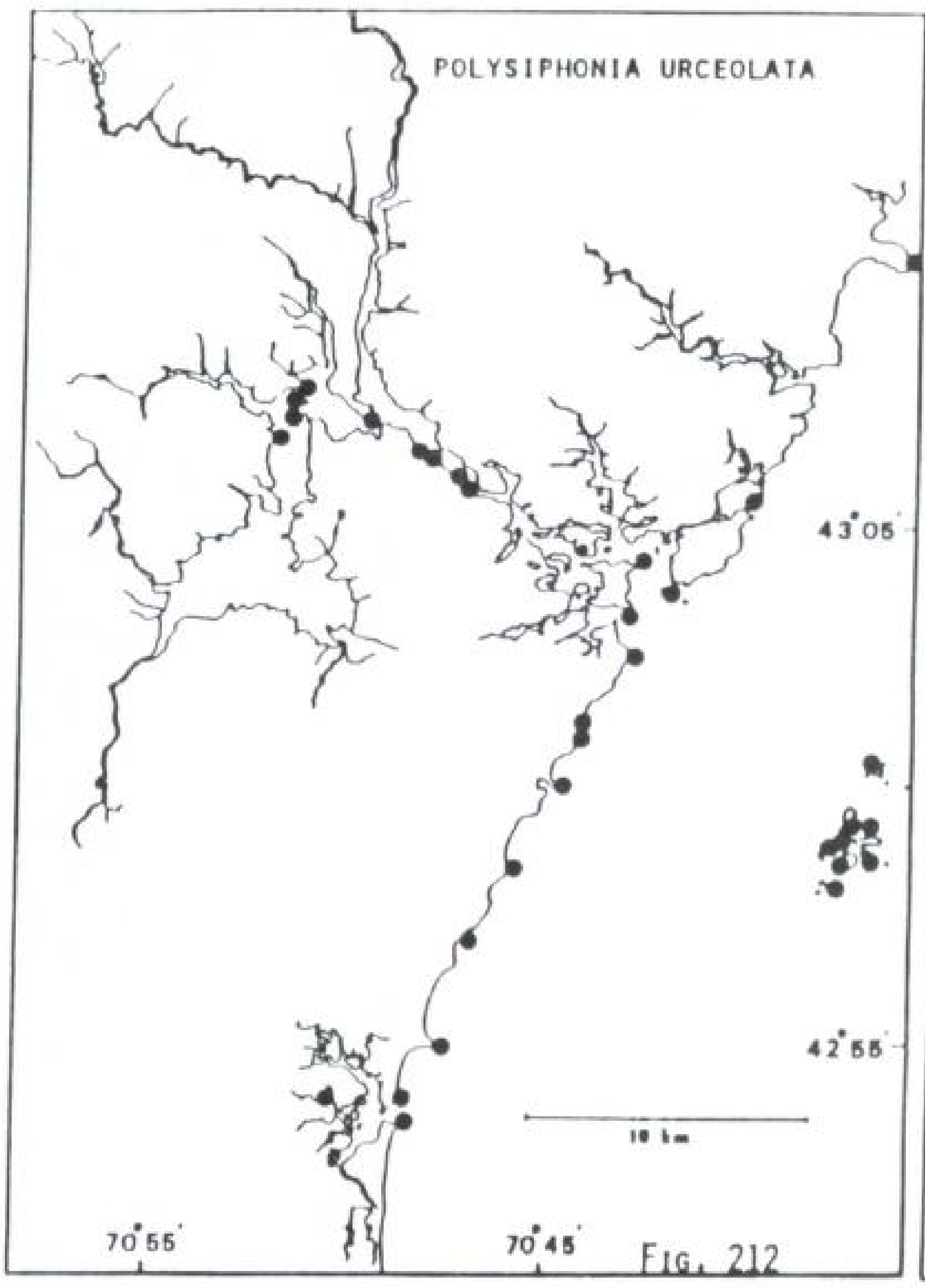


FIG. 212

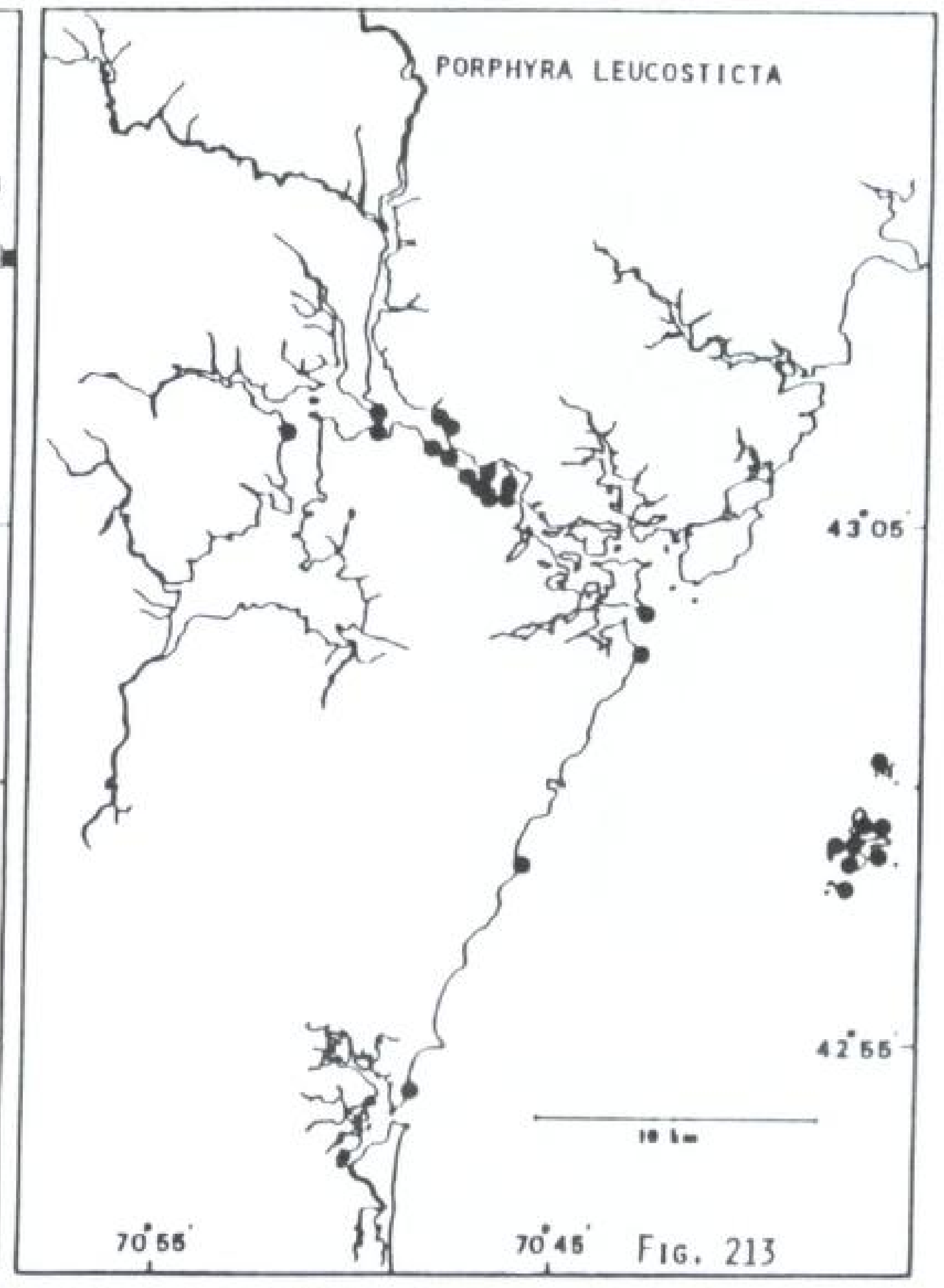


FIG. 213

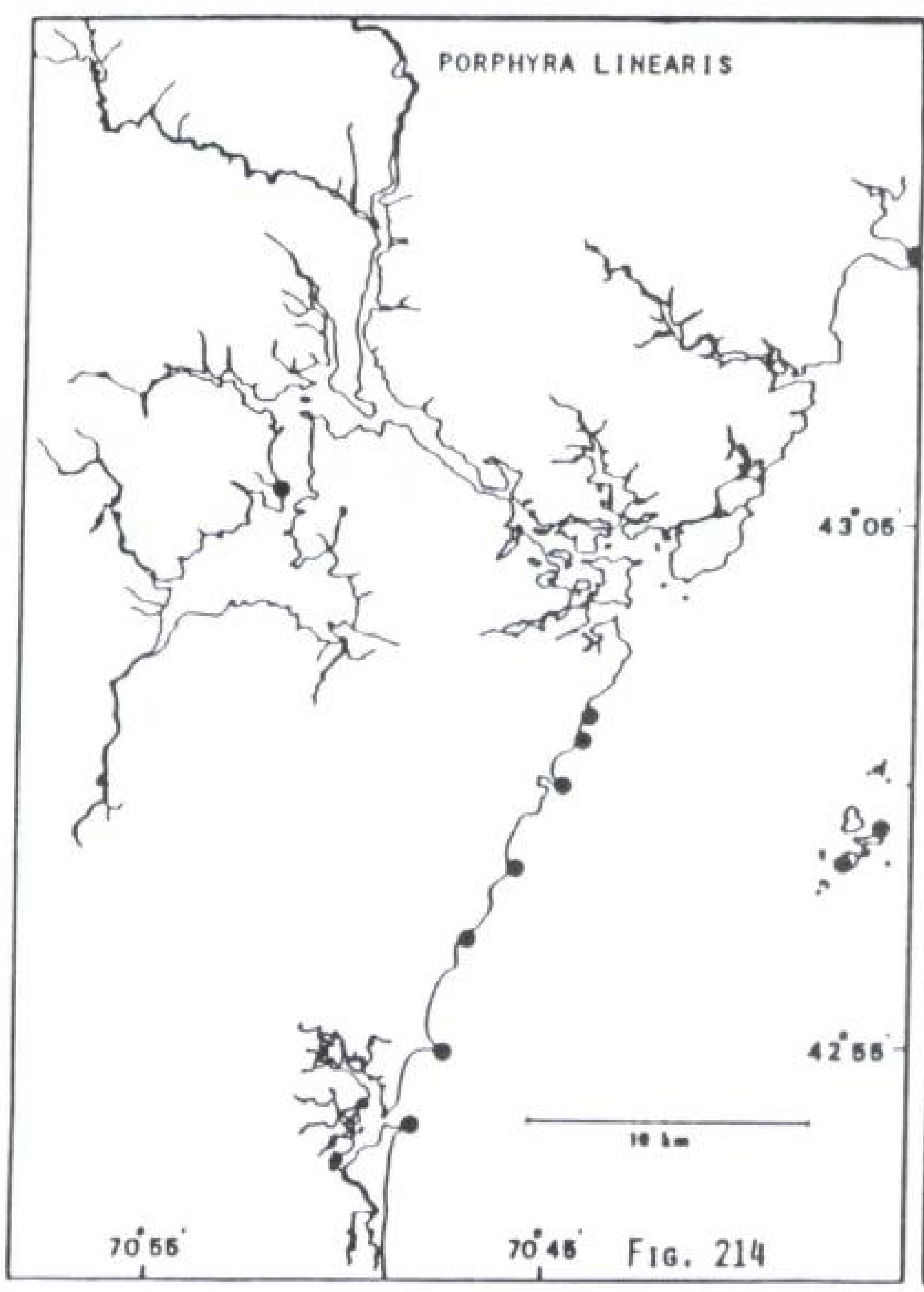


FIG. 214

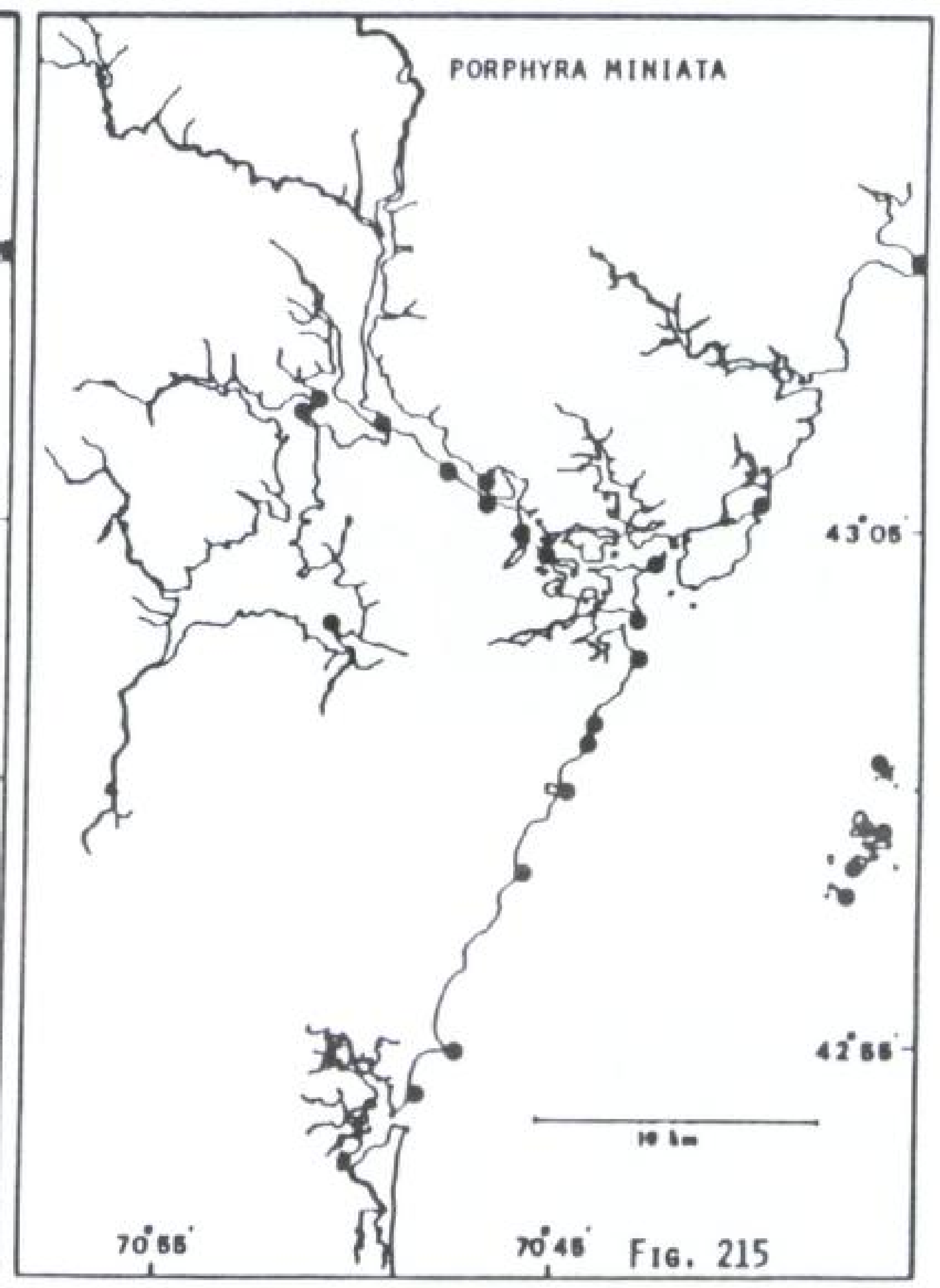


FIG. 215

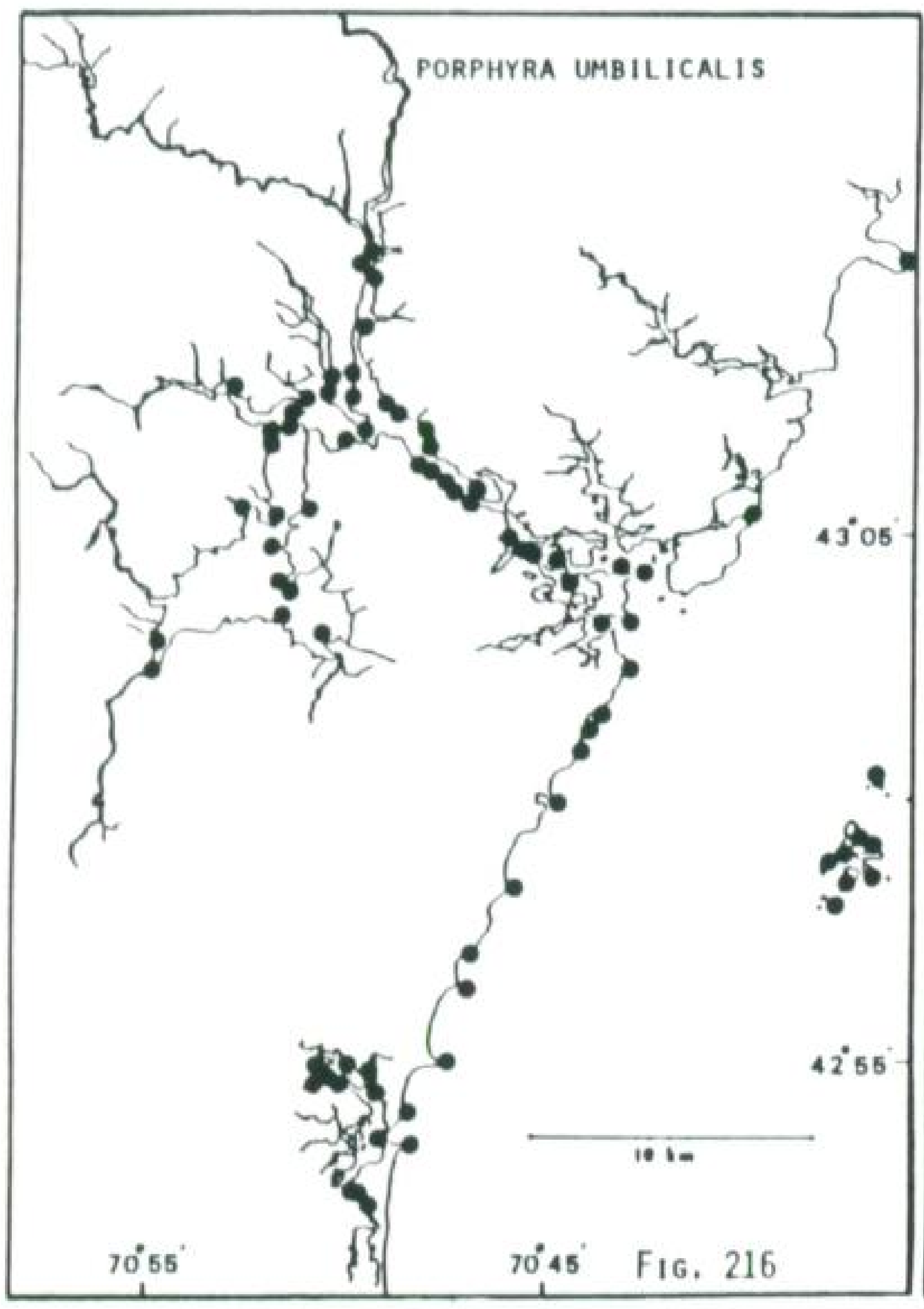


FIG. 216

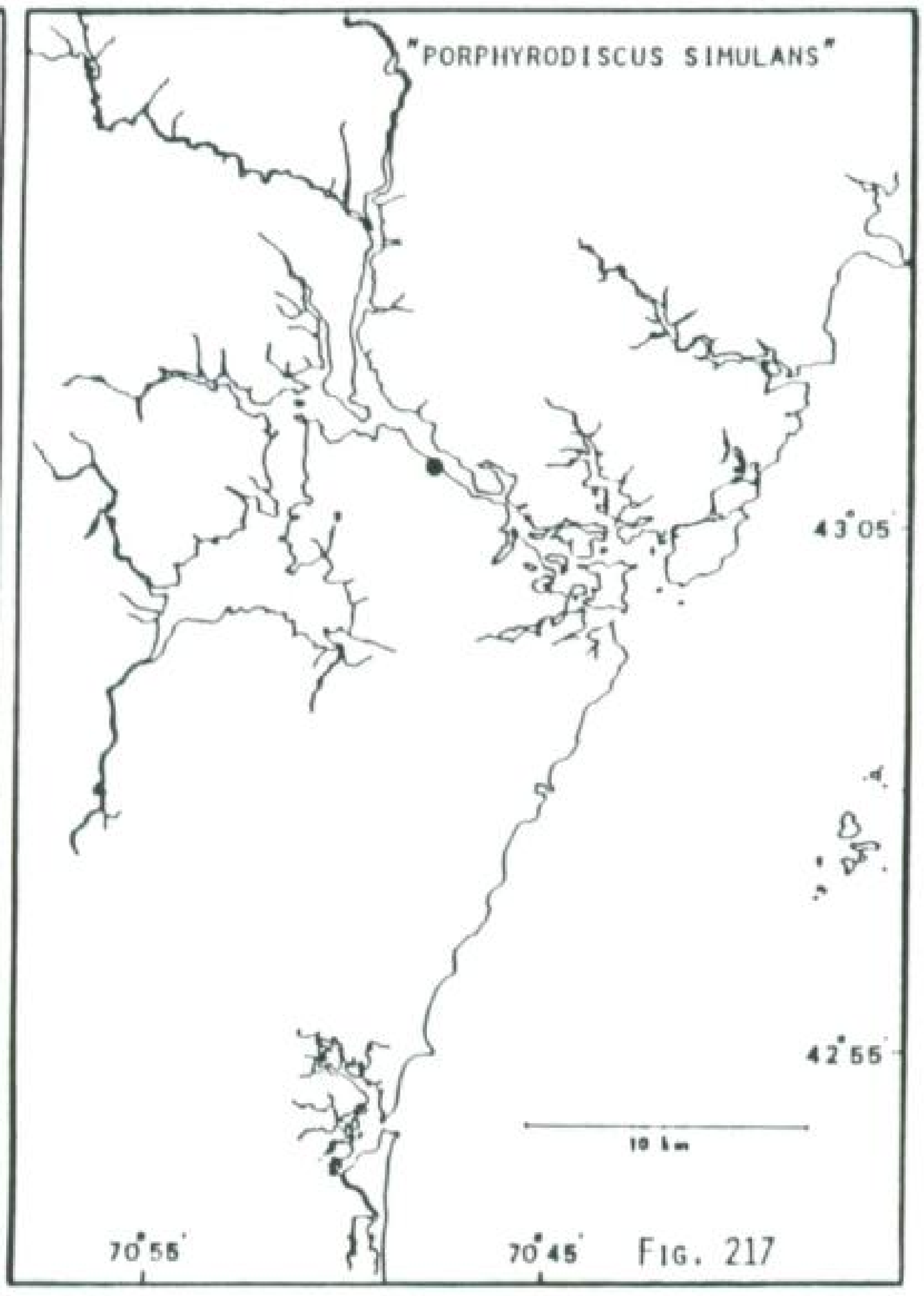


FIG. 217

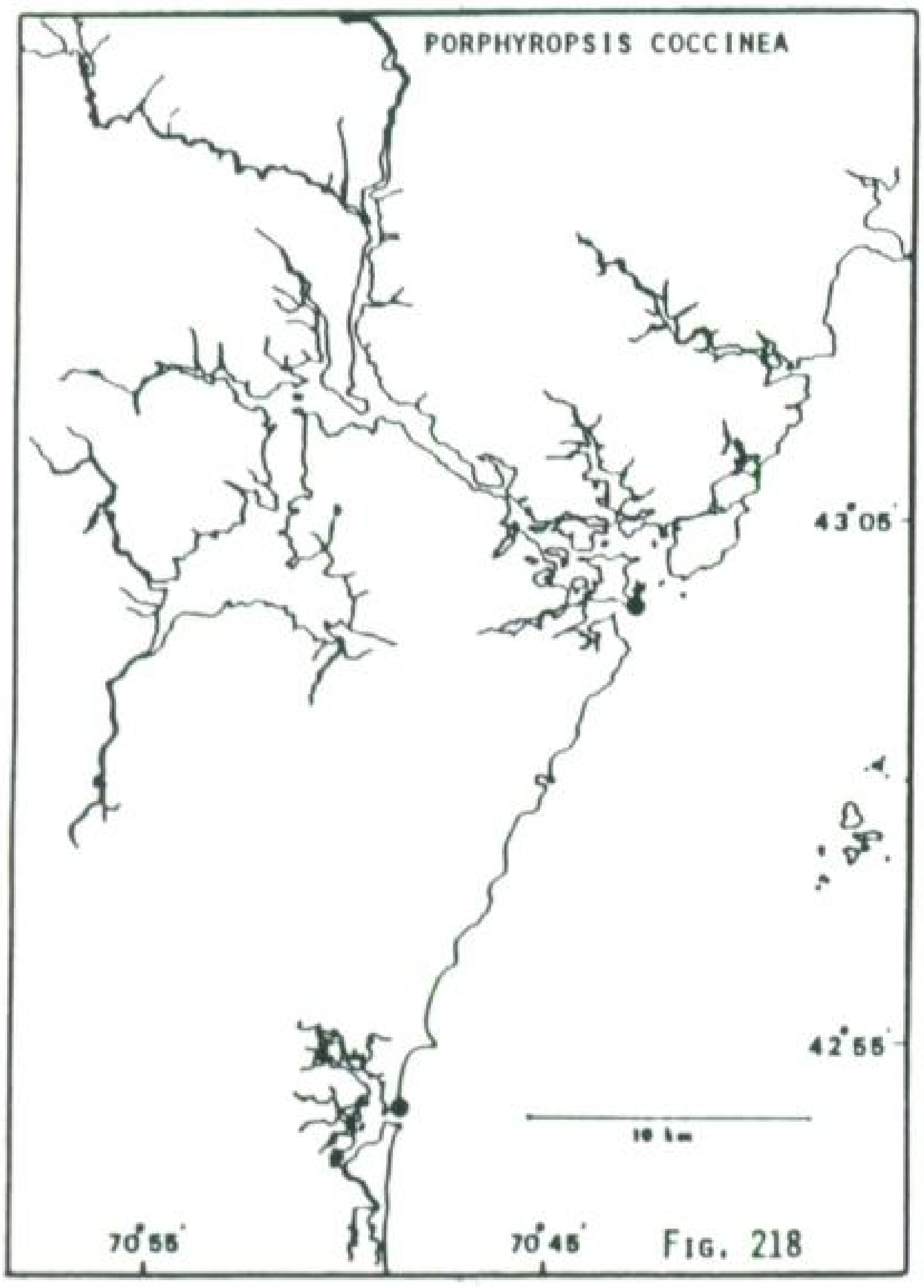


FIG. 218

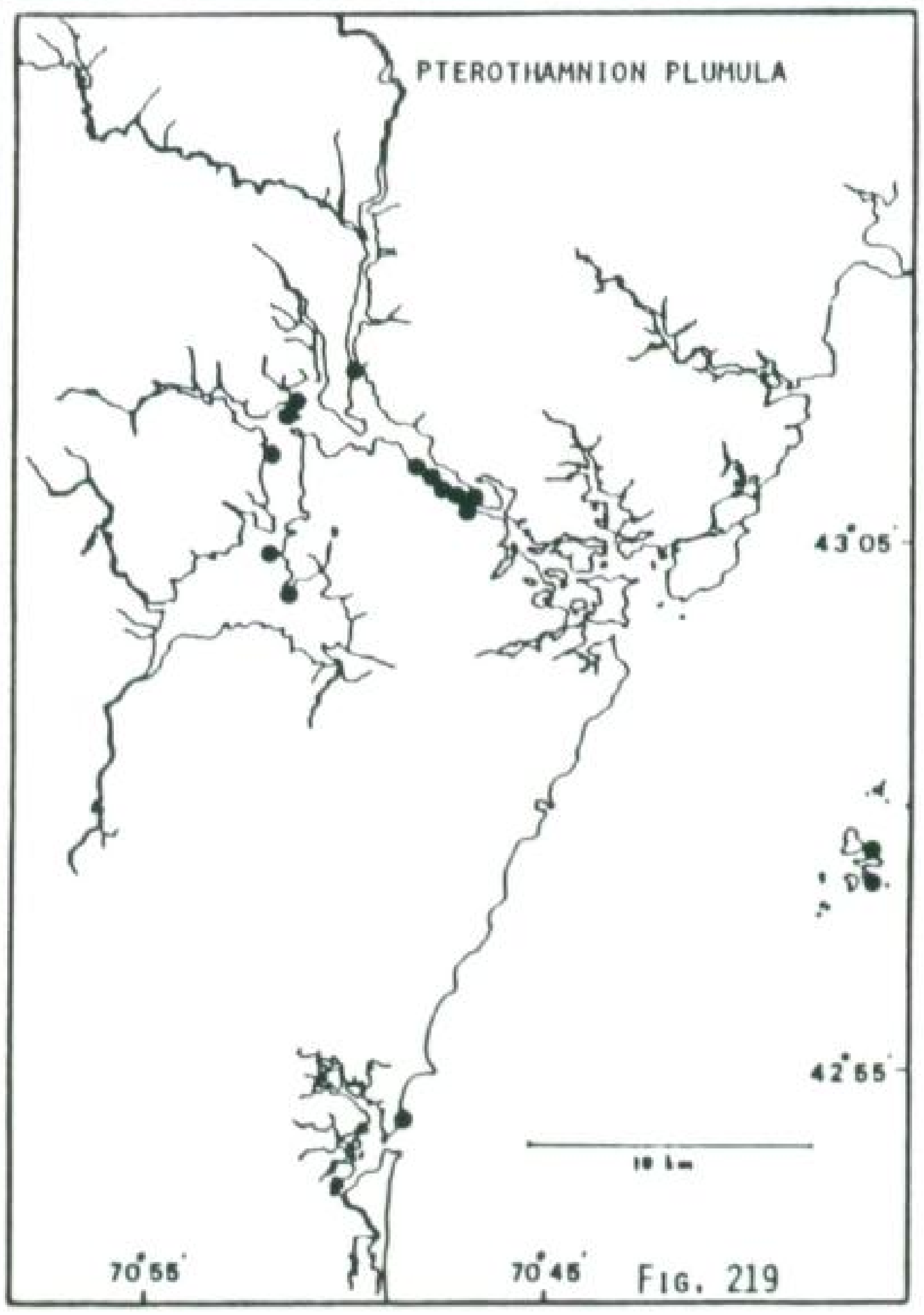
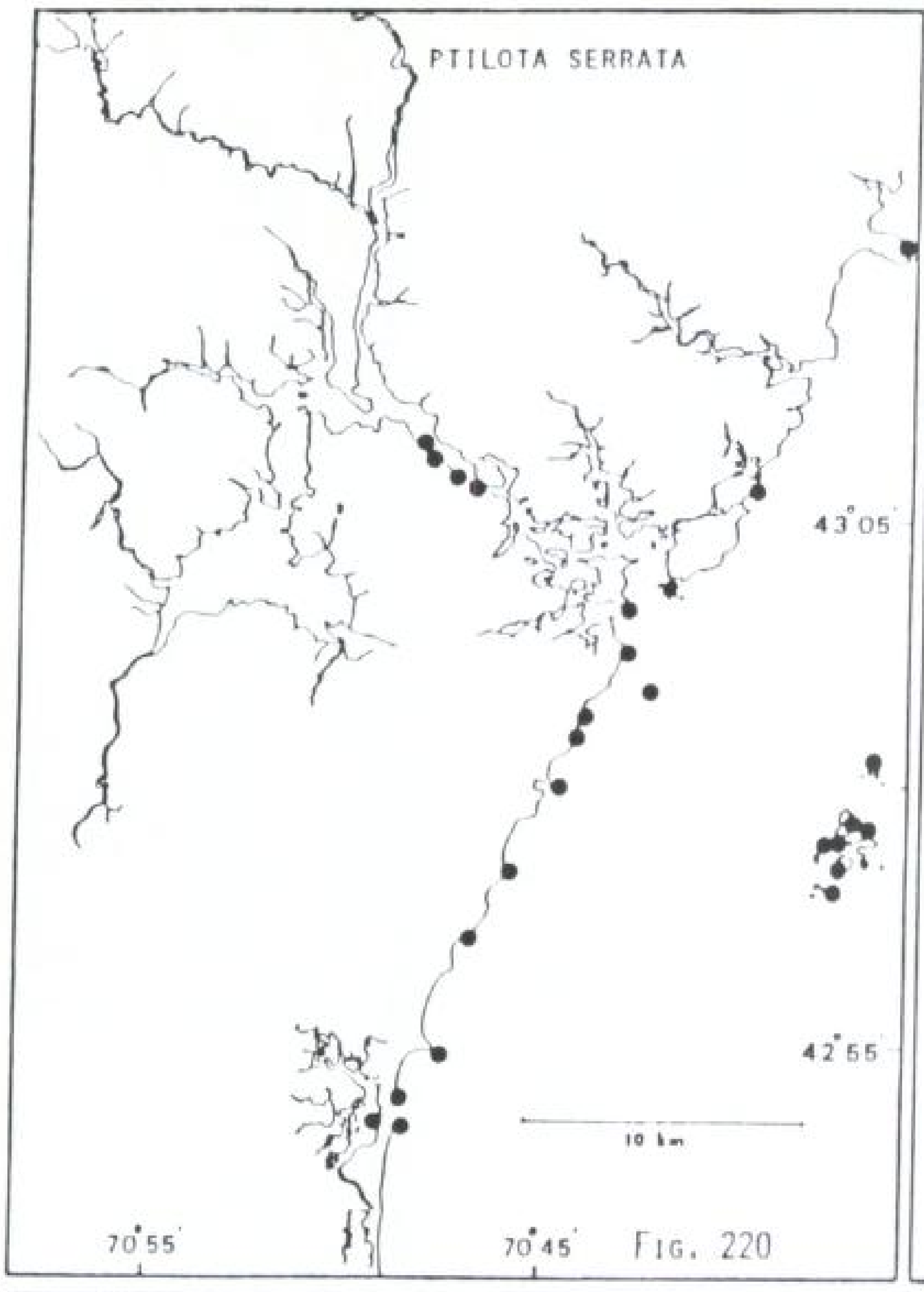


FIG. 219



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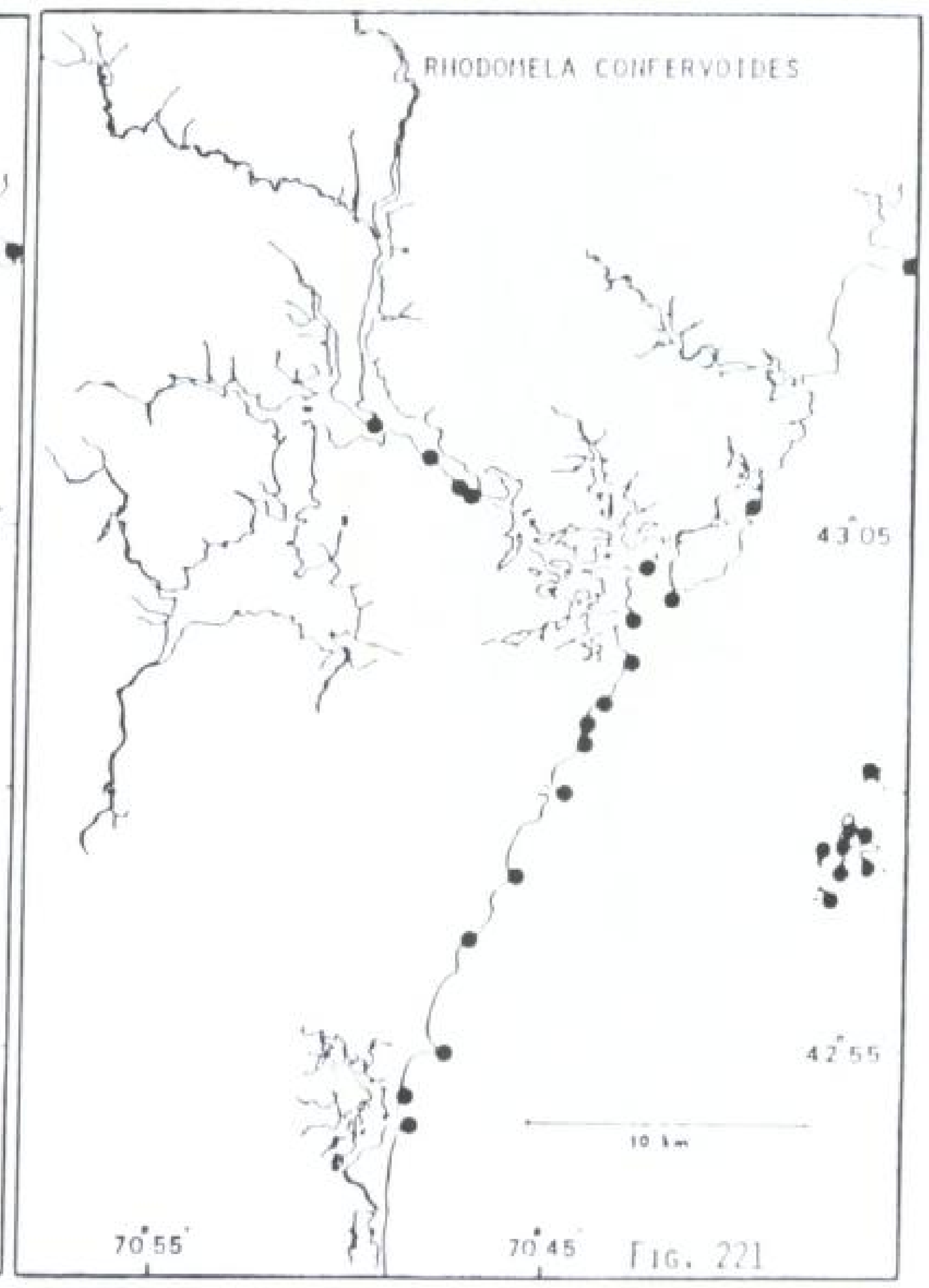


Fig. 221

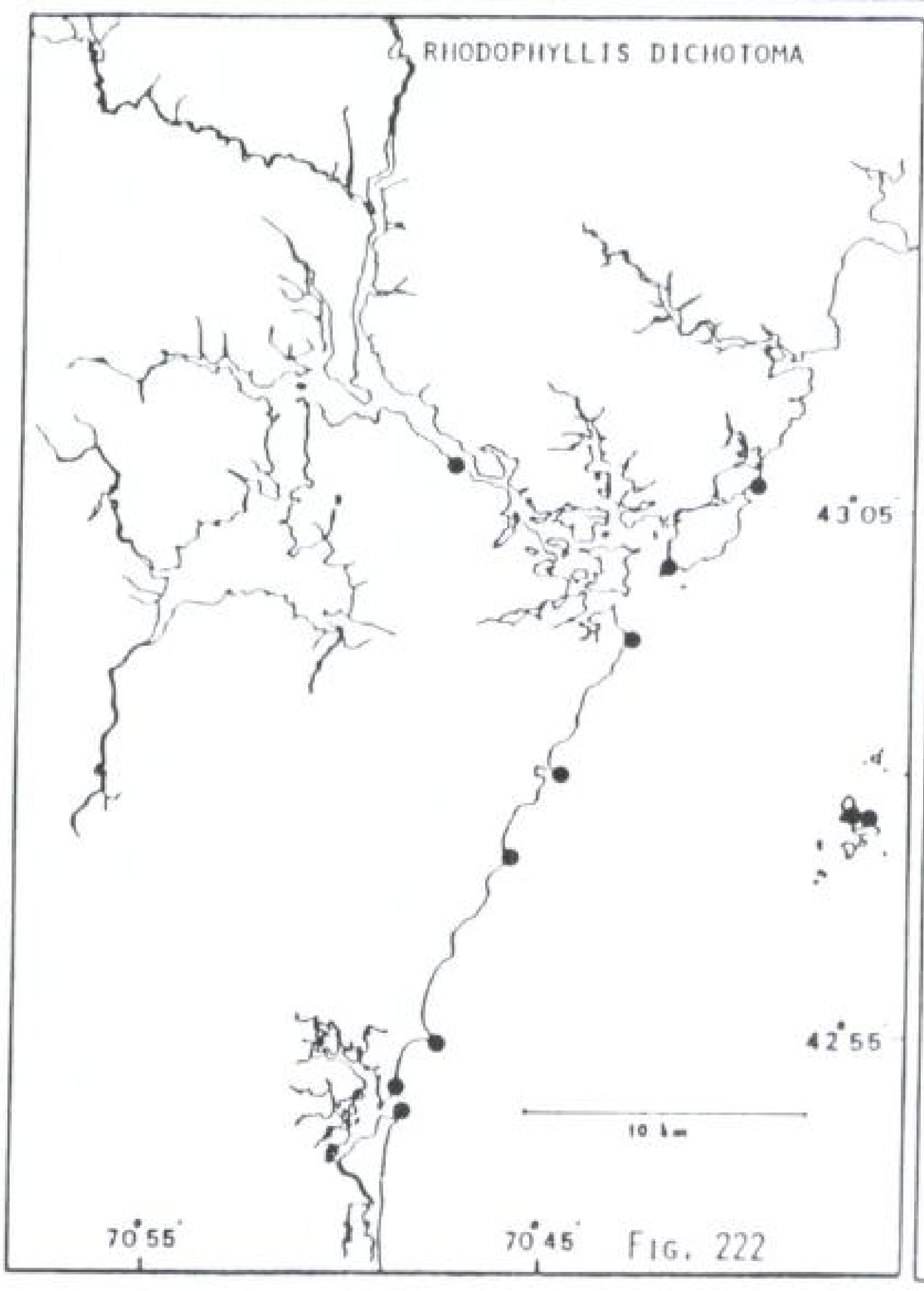
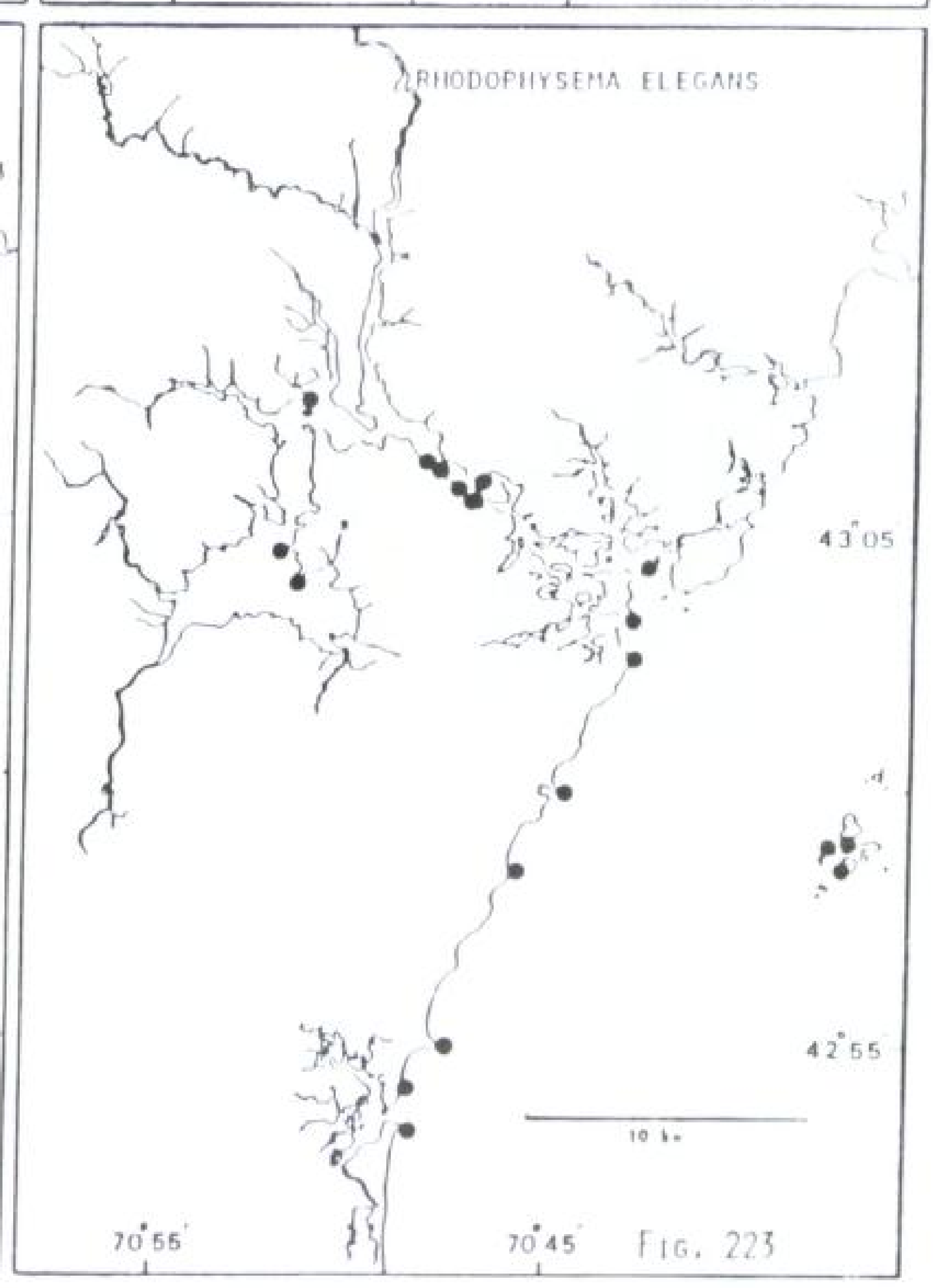


Fig. 222



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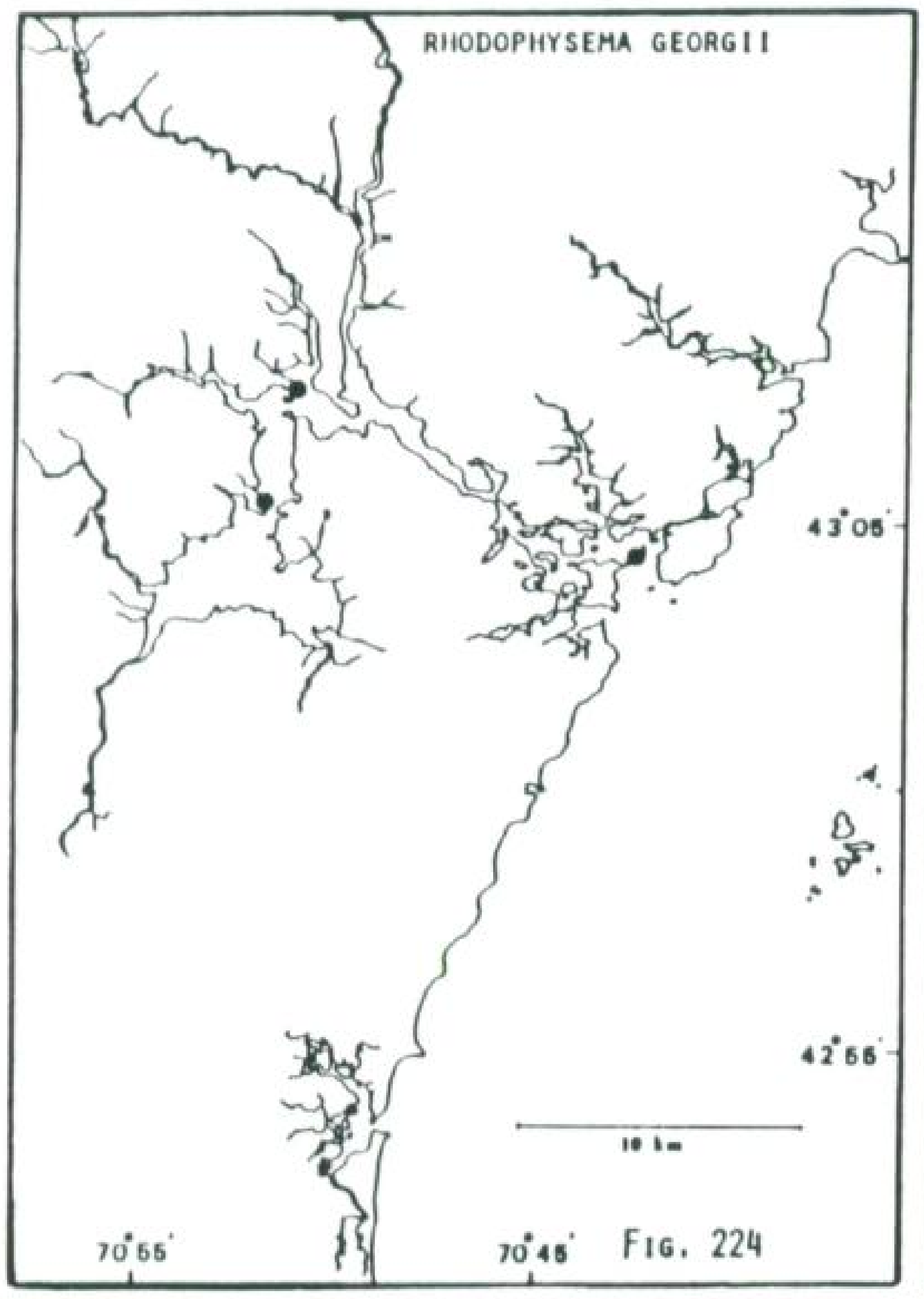


Fig. 224

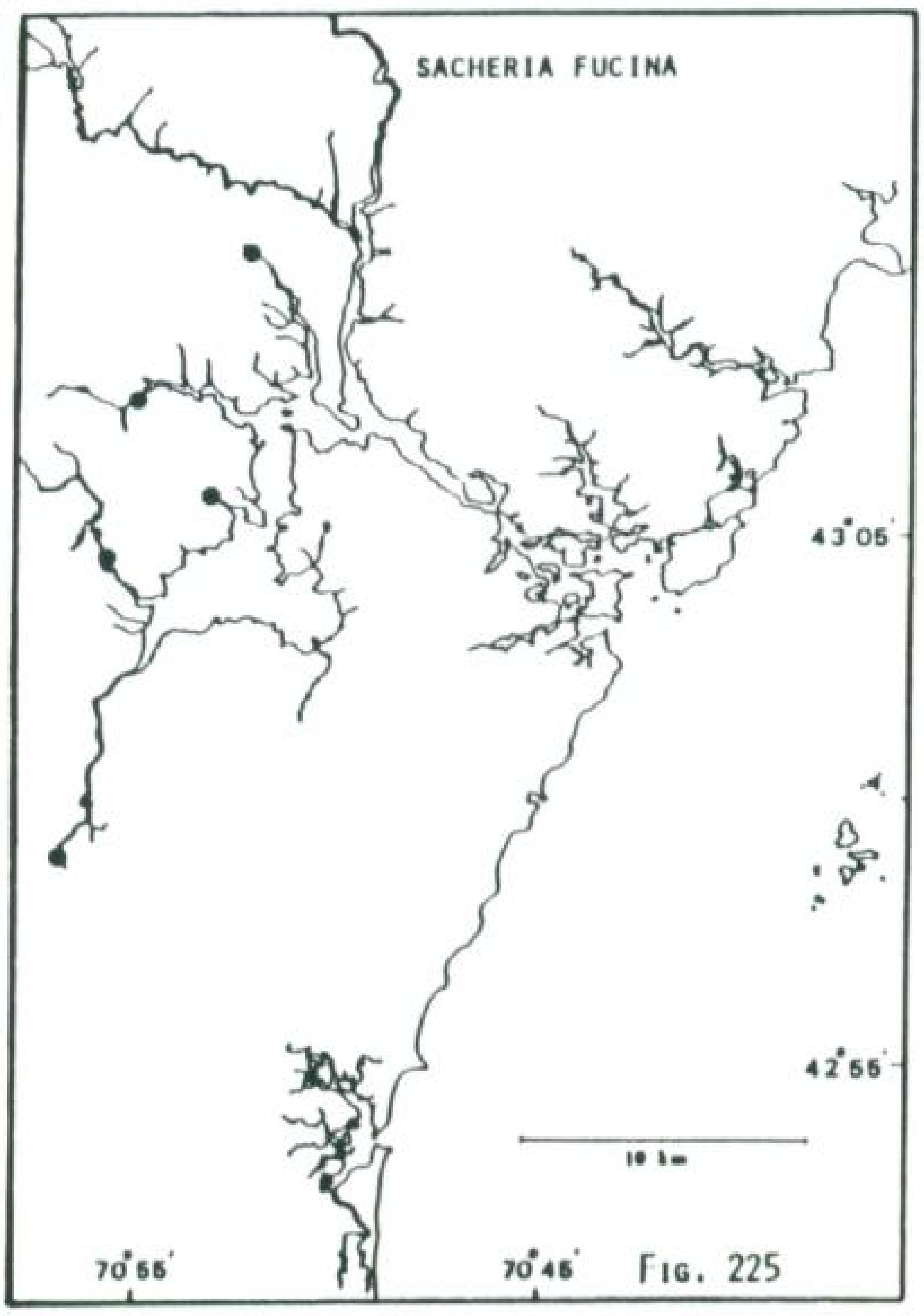


Fig. 225

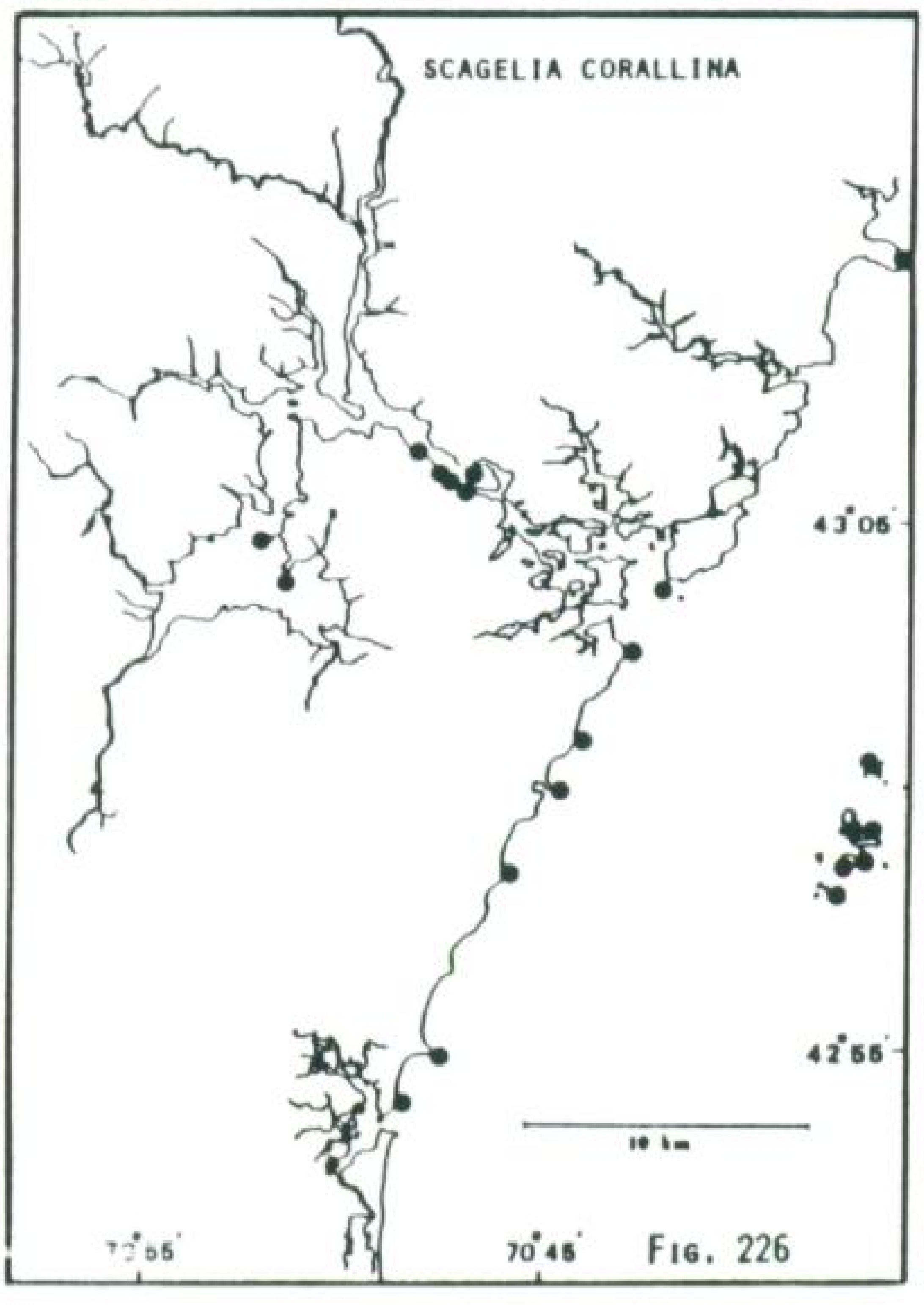
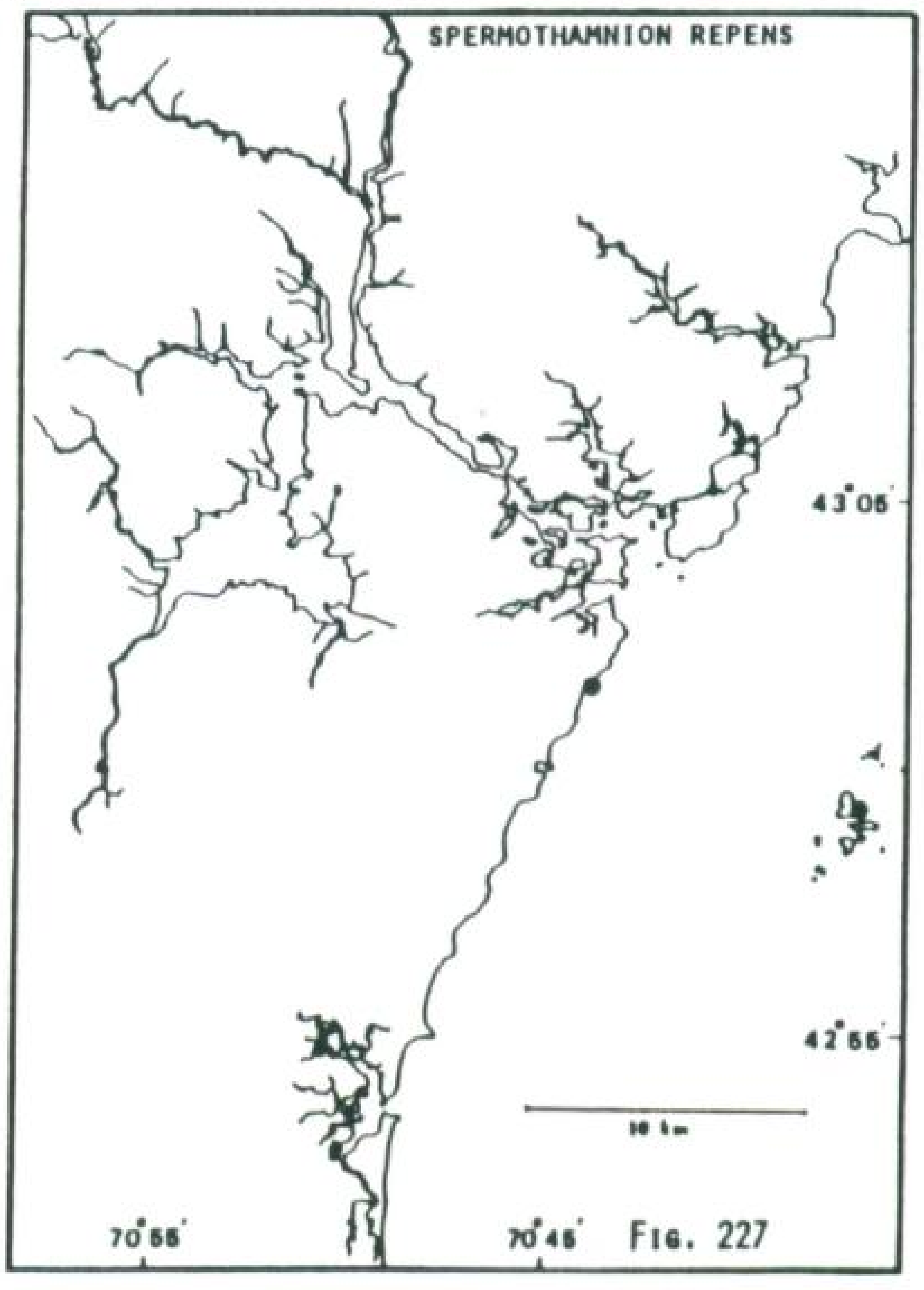


Fig. 226



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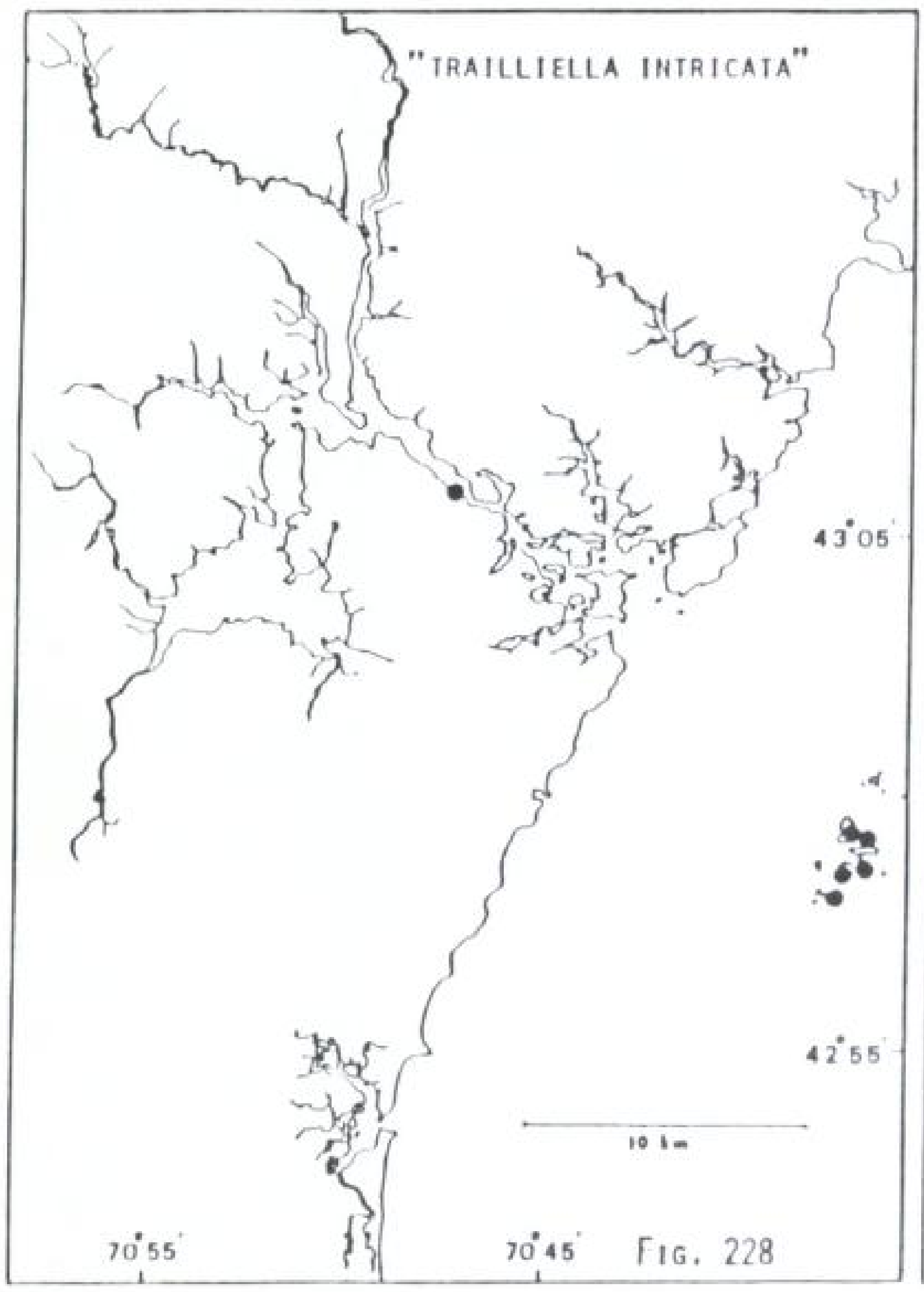

FIG. 228

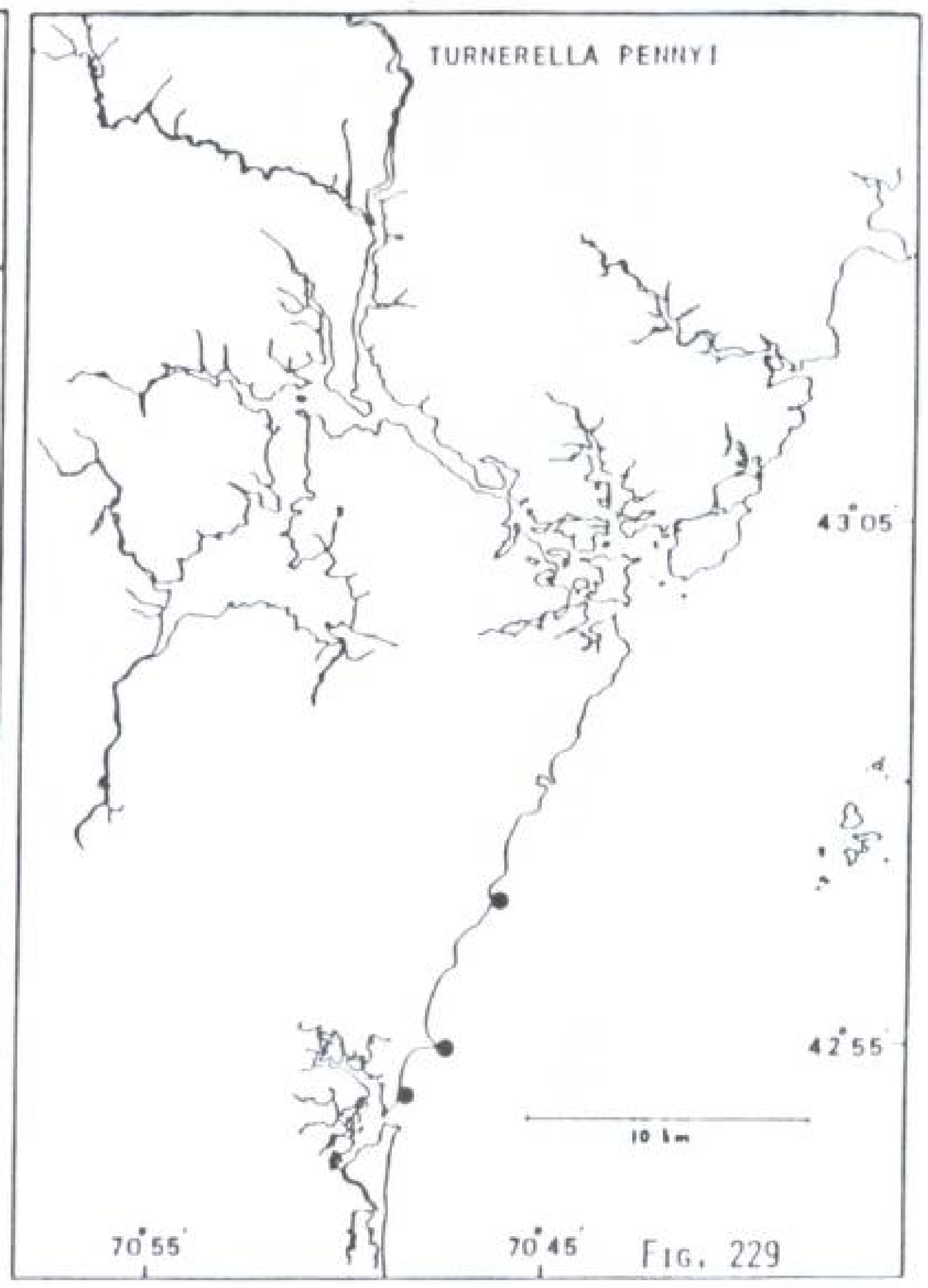

FIG. 229

APPENDIX

NEARSHORE OPEN COAST BETWEEN SOUTHERN MAINE AND NEW HAMPSHIRE

Station Number	Latitude and Longitude	Description
C1	43°12′16″N, 70°34′W	Bald Head Cliff, Ogunquit, Maine
C2	43°09′56″N, 70°35′25″W	Nubble Light, Cape Neddick, Maine
C3	43°05′26″N, 70°30′32″W	Sea Point, Maine
C4	43°03′38″N, 70°41′42″W	Kittery Point, Maine
C5	43°03′22″N, 70°42′49″W	Jaffrey Point, Fort Stark, New Hampshire
C6	43°02′15″N, 70°43′20″W	Odiorne's Point, Frost Point, Fort Dearborn, New Hampshire
C7	43°01′30″N, 70°43′20″W	Seal Rocks, New Hampshire
C8	43°01′20″N, 70°42′15″W	Gunboat Shoals, New Hampshire
C9	43°01′25″N, 70°43′40″W	North Wallis Sands, New Hampshire
C10	43°01′00″N, 70°43′55″W	Concord Point, New Hampshire
C11	43°00′05″N, 70°44′30″W	Ragged Neck, New Hampshire
C12	42°58′20″N, 70°45′33″W	Rye Ledge, New Hampshire
C13	42°57′30″N, 70°46′30″W	Little Boar's Head, New Hampshire
C14	42°57′00″N, 70°46′44″W	Godfrey's Ledge, North Hampton, New Hampshire
C15	42°55′05″N, 70°47′18″W	Great Boar's Head, New Hampshire
C16	42°54′30″N, 70°48′30″W	Hampton Beach, New Hampshire
C17	42°53′30″N, 70°48′45″W	Bound Rock, area in the immediate vicinity of Beckman's Point, near mouth of Hampton Harbor, Hampton, New Hampshire

GREAT BAY ESTUARY SYSTEM
PISCATAQUA RIVER

(New Hampshire/Maine)

Station No.	Latitude and Longitude	Miles From Coast	Description
P1	43°04′00″N, 70°41′46″W	.05	Gerrish Island, at Fort Foster, northeast of Wood Island, Kittery, Maine
P2	43°03′31″N, 70°42′58″W	.2	Wentworth Point, Little Harbor, New Castle, New Hampshire
P3	43°03′20″N, 70°43′18″W	.1	Little Harbor Estuary, point northeast of Frost Point, New Castle, New Hampshire
P4	43°03′01″N, 70°43′55″W	.85	Witch Creek, Rye, New Hampshire
P5	43°03′25″N, 70°44′20″W	1.3	Sagamore Creek, Portsmouth, New Hampshire
P6	43°03′34″N, 70°44′15″W	1.25	Goose Island, near mouth of Sagamore Creek, Portsmouth, New Hampshire
P7	43°04′20″N, 70°42′30″W	.8	Fort Constitution, Fort Point, New Castle, New Hampshire
P8	43°04′24″N, 70°42′56″W	1.4	Salamander Point, New Castle, New Hampshire
P9	43°04′19″N, 70°43′47″W	2.1	Shaw's Hill, New Castle, New Hampshire
P10	43°04′14″N, 70°43′48″W	2.1	Riverside Cemetery, New Castle, New Hampshire
P11	43°04′12″N, 70°44′26″W	2.7	Shapleigh Island, Portsmouth, New Hampshire
P12	43°04′29″N, 70°44′48″W	2.8	Pierce Island, Portsmouth, New Hampshire
P13	43°04′44″N, 70°45′12″W	3.4	Memorial Bridge and adjacent Fisherman's Pier area, also Electric Plant, Portsmouth, New Hampshire
P14	43°04′46″N, 70°45′28″W	3.6	Ceres Street, upstream from P13, Portsmouth, New Hampshire
P15	43°05′09″N, 70°45′40″W	4	Bridge at Rte. 1 bypass, west bank, Portsmouth, New Hampshire

Great Bay Estuary System/Piscataqua River (NH,ME) (Cont.)

Station No.	Latitude and Longitude	Miles From Coast	Description
P16	43°05′13″N, 70°45′52″W	4.3	Freeman's Point, Normandeau Schiller Site No. 12 (New Hampshire side at Maine-New Hampshire Rte. 1 bypass bridge) Portsmouth, New Hampshire
P17	43°05′26″N, 70°45′39″W	4.5	Normandeau Schiller Site No. 13 (on Maine side in creek west of Maine-New Hampshire Rte. 1 bypass bridge) end of Adams Lane, Kittery, Maine
P18	43°05′36″N, 70°46′08″W	4.7	Atlantic Heights and Normandeau Schiller Site No. 14 (west of "new" bridge—New Hampshire side) Portsmouth, New Hampshire
P19	43°05′43″N, 70°46′10″W	4.9	Normandeau Schiller Site No. 15 (east of navigation point and high tension towers) Eliot, Maine
P20	43°05′52″N, 70°46′03″W	5.0	Spinney Creek, at south Eliot Road Bridge, Eliot, Maine (including Jerry's Marina)
P21	43°05′40″N, 70°46′46″W	5.0	Dock at Sprague Terminal, Portsmouth, New Hampshire
P22	43°05′41″N, 70°46′51″W	5.3	Normandeau Schiller Site No. 16 (in cove east of Schiller Generating Station) Portsmouth, New Hampshire
P23	43°05′51″N, 70°47′02″W	5.5	Schiller Station, Portsmouth, New Hampshire
P24	43°06′02″N, 70°46′52″W	5.6	Normandeau Schiller Site No. 17 and 17D (Maine side at end of Long Reach Farm) Eliot, Maine
P25	43°06′15″N, 70°47′47″W	5.6	Newington Power Station and Normandeau Schiller Sites Nos. 18–40 (between Schiller Plant and Simplex Pier; benthic stations 300′ offshore LW marsh, and 500′ from HW mark) and Normandeau Schiller

			Transects A–C, Simplex Plant–Pier, Newington, New Hampshire
P26	43°06′21″N, 70°47′49″W	6.5	Normandeau Schiller Site No. 42 (on the west side of the Simplex Pier) and Normandeau Schiller Transects D & E, Newington, New Hampshire
P27	43°06′32″N, 70°47′34″W	6.45	Normandeau Schiller Site No. 19 (one-half mile east of Frankfort Island) Park Street, Eliot, Maine
P28	43°06′38″N, 70°47′47″W	6.6	Public landing end of Green Acre Road and just upstream and opposite from Simplex Dock, Eliot, Maine
P29	43°06′28″N, 70°47′58″W	6.7	Normandeau Schiller Site No. 44 (in a large cove west of the Simplex Pier) and Union Oil Terminal, Newington, New Hampshire
P30	43°06′33″N, 70°48′13″W	6.85	Town Landing, Newington, New Hampshire
P31	43°06′44″N, 70°48′32″W	7.1	Normandeau Schiller Site No. 46 (east of old shipyard and west of Union Oil Terminal), Newington, New Hampshire
P32	43°06′53″N, 70°47′57″W	7	Mast Cove (Searles Cove) and Normandeau Schiller Site No. 21 (in Mast Cove behind Frankfort Island) Eliot, Maine
P33	43°06′52″N, 70°48′08″W	7.05	Frankfort Island, Eliot, Maine
P34	43°07′07″N, 70°48′06″W	7.4	Mast Cove (Searles Cove) and Normandeau Schiller Site No. 23 (east of Adlington Creek), Eliot, Maine
P35	43°06′58″N, 70°48′42″W	7.6	Normandeau Schiller Site No. 48 (west of Atlantic terminal), Newington, New Hampshire
P36	43°07′00″N, 70°49′24″W	8.2	Bloody Point, opposite Hilton Park and Normandeau Schiller Site No. 50 (cove on northeast side of General Sullivan Bridge), Newington, New Hampshire
P37	43°07′16″N, 70°48′22″W	7.65	North of Adlington Creek mouth, Eliot, Maine

Great Bay Estuary System/ Piscataqua River (NH, ME) (Cont.)

Station No.	Latitude and Longitude	Miles From Coast	Description
P38	43°07′18″N, 70°48′45″W	7.8	East bank at first promontory upstream from Adlington Creek at a public dock, Eliot, Maine
P39	43°07′25″N, 70°49′02″W	7.95	East bank opposite General Sullivan Bridge and Normandeau Schiller Site No. 25 (on Maine side directly across from the eastern point of the General Sullivan Bridge) Eliot, Maine
P40	43°07′17″N, 70°49′25″W	8.2	Offshore ledge upstream from Dover Point, Dover, New Hampshire
P41	43°07′33″N, 70°50′05″W	8.9	Pomeroy Cove, Dover, New Hampshire
P42	43°07′38″N, 70°49′16″W	8.55	East bank along River Road and approximately opposite Pomeroy Cove (Hilton Park is opposite this), Eliot, Maine
P43	43°07′51″N, 70°49′21″W	8.7	Stacey Creek mouth, Eliot, Maine
P44	43°07′55″N, 70°49′25″W	8.95	East bank, first major promontory upstream of Stacey Creek, Eliot, Maine
P45	43°07′45″N, 70°49′59″W	8.95	West bank at the end of Cote Drive, Dover, New Hampshire
P46	43°08′05″N, 70°49′38″W	9.35	East bank opposite Pineview Drive ending at Rogers Pt. Road, Eliot, Maine
P47	43°08′09″N, 70°49′58″W	9.45	West bank, Pineview Drive ending, Dover, New Hampshire
P48	43°08′29″N, 70°49′48″W	9.8	East bank just southeast and opposite from the end of Roberts Road, Eliot, Maine
P49	43°08′38″N, 70°50′04″W	10	West bank at the end of Roberts Road, Dover, New Hampshire
P50	43°08′48″N, 70°49′55″W	10.1	East bank, opposite and southeast from Riverside Drive, Eliot, Maine
P51	43°09′01″N, 70°50′07″W	10.4	West bank just northeast of Riverside Drive, Dover, New Hampshire

P52	43°08′59″N, 70°49′53″W	10.45	East bank just south of Sturgeon Creek, opposite Riverside Drive, Eliot, Maine
P53	43°09′11″N, 70°49′48″W	10.7	East bank just south of mouth of Sturgeon Creek, Eliot, Maine
P54	43°09′25″N, 70°49′40″W	10.95	East bank just north of mouth of Sturgeon Creek, at Tidy Road, Eliot, Maine
P55	43°09′44″N, 70°49′54″W	11.3	Just southeast of the end of Dover Neck Road, west bank upstream from Sturgeon Creek, Dover, New Hampshire
P56	43°10′03″N, 70°49′38″W	11.7	East bank at large tennis court facility, approximately mid way between Sturgeon Creek and the mouth of the Salmon Falls River, at the end of Houde Road, Eliot, Maine
P57	43°10′16″N, 70°49′43″W	12	Northeast of Dover Neck Road, near power lines, Dover, New Hampshire
P58	43°10′19″N, 70°49′30″W	12	East bank opposite Dover Neck Road, near power lines opposite Gould Corner, Eliot, Maine
P59	43°10′25″N, 70°49′30″W	12.1	West bank just south of Cocheco River junction, Dover, New Hampshire

LITTLE BAY
(New Hampshire)

Station No.	Latitude and Longitude	Miles from Coast	Description
LB1	43°07′07″N, 70°49′42″W	8.6	Dover Point, including Hilton Park and pilings at Sullivan's Bridge, Dover
LB2	40°07′17″N, 70°50′04″W	8.95	Benn's Marina, west bank of Dover Point and upstream from Hilton Park, Dover
LB3	43°06′57″N, 70°49′46″W	8.7	Point between Great Bay Marina and General Sullivan Bridge, and just

Little Bay (NH) (Cont.)

Station No.	Latitude and Longitude	Miles From Coast	Description
			northwest of Newington Station, Newington
LB4	43°06′56″N, 70°50′02″W	8.9	Great Bay Marina, point due west of LB3, Newington
LB5	43°06′54″N, 70°50′34″W	9.45	Broad Cove, Newington
LB6	43°07′21″N, 70°50′45″W	9.5	Submarine ledge, southeast of Goat Island, a peninsula in Little Bay, Newington
LB7	43°07′45″N, 70°51′08″W	10.2	Cedar Point including shoreline of Little Bay and Royals Cove, Durham
LB8	43°07′27″N, 70°51′19″W	10	Goat Island and adjacent rock outcrops, Newington
LB9	43°07′13″N, 70°51′47″W	11	Fox Point, Newington
LB10	43°07′14″N, 70°52′10″W	11.1	Durham Point except northwest tip along the bank of the Oyster River (01), Durham
LB11	43°06′57″N, 70°51′57″W	11.4	Langley's Island, formerly Sassafrass Island; Seal Rocks and adjacent offshore ledge, Durham
LB12	43°06′54″N, 70°52′03″W	11.45	End of Colony Cove, just south of Durham Point, Durham
LB13	43°06′23″N, 70°52′14″W	11.55	East bank of Little Bay at junction of power cable, Durham
LB14	43°05′56″N, 70°52′02″W	11.9	Stone House, east bank and south of LB13, approximately 2/3 of the distance between Adams Point to Langley's Island, Durham
LB15	43°05′51″N, 70°52′11″W	12	In front of P. Sawyer's old house, Durham
LB16	43°05′43″N, 70°52′07″W	12.25	Adams Point, Durham
LB17	43°05′47″N, 70°51′16″W	12	First promontory north of Welch Cove, Newington
LB18	43°05′41″N, 70°51′15″W	12.15	Welch Cove, Newington

LB19	43°05′35″N, 70°51′30″W	12.25	Second promontory south of Welch Cove, Newington
LB20	43°05′32″N, 70°51′44″W	12.2	Furber Strait, Durham/Newington
LB21	43°05′24″N, 70°51′39″W	12.35	Promontory due east of Adams Point, Newington

GREAT BAY
(New Hampshire)

Station No.	Latitude and Longitude	Miles From Coast	Description
GB1	43°05′52″N, 70°53′52″W	13.9	Crommet Creek at Bay Road Bridge, Durham
GB2	43°05′13″N, 70°52′21″W	12.9	Footman Islands, Durham
GB3	43°05′05″N, 70°52′48″W	13.35	First major promontory southwest of Footman Island, Durham
GB4	43°04′49″N, 70°53′25″W	15	Third major promontory southwest of Footman Island, Newmarket
GB5	43°04′03″N, 70°54′25″W	15.3	Moody's Point, end of Smith Garrison Road (except for L2 just upstream from Moody's Point), Newmarket
GB6	43°03′50″N, 70°54′45″W	15.65	Shackford Point, Newmarket (except for L1, second promontory upstream on Shackford Point)
GB7	43°03′39″N, 70°54′50″W	15.8	West bank, due south of Shackford Point, near mouth of Squamscott River, Newmarket
GB8	43°03′46″N, 70°54′34″W	14.7	Sandy Point, Greenland
GB9	43°03′35″N, 70°52′17″W	14.5	Brackett's Point, Greenland
GB10	43°03′32″N, 70°51′42″W	14.65	Weeks Point, Greenland
GB11	43°03′05″N, 70°51′16″W	15.2	Point due west of Pierce Point, just beyond mouth of Winnicut River, Greenland
GB12	43°03′14″N, 70°50′48″W	15.5	Pierce Point, Greenland
GB13	43°04′05″N, 70°50′48″W	15.05	Fabyan's Point, Newington
GB14	43°04′08″N, 70°51′47″W	13.85	Nannie Island, Newington
GB15	43°04′16″N, 70°51′40″W	13.75	Woodman Point, Newington
GB16	43°04′53″N, 70°51′56″W	13	Thomas Point, Newington

BELLAMY RIVER
(NEW HAMPSHIRE)

Station No.	Latitude and Longitude	Miles From Coast	Description
B1	43°07′47″N, 70°50′52″W	10.4	Mouth, east bank near Scammel Bridge pilings, Dover
B2	43°08′06″N, 70°50′36″W	10.75	East bank, opposite Clements' Point and near toll plaza, Dover
B3	43°08′09″N, 70°51′02″W	10.75	Clements' Point, Dover
B4	43°08′49″N, 70°50′54″W	11.6	West bank, opposite from Bellamy Lane, Dover
B5	43°09′21″N, 70°51′17″W	12.3	West and east banks at Nute Road, Dover
B6	43°09′47″N, 70°51′23″W	12.8	East bank at Cushing Road, Dover
B7	43°09′57″N, 70°51′37″W	13.1	East bank, end of Spur Road near Greek cemetery, Dover
B8	43°10′16″N, 70°51′52″W	13.5	West bank, near the end of Mast Road, Dover
B9	43°10′33″N, 70°52′20″W	14	West bank, opposite Mill Street, Dover
B10	43°10′39″N, 70°52′30″W	14.25	Headwaters, below tidal dam, near Sawyer's Mills, Dover

COCHECO RIVER
(NEW HAMPSHIRE)

Station No.	Latitude and Longitude	Miles From Coast	Description
C1	43°10′44″N, 70°49′48″W	12.6	Mouth, on east bank and opposite peninsula separating Cocheco from Piscataqua River, Dover
C2	43°10′58″N, 70°50′09″W	13.2	West bank, just opposite and somewhat south of the end of Three Rivers Road, Dover
C3	43°11′12″N, 70°50′17″W	13.3	East bank at the mouth of Fresh Creek, Dover
C4	43°11′10″N, 70°50′27″W	13.5	West bank, just opposite mouth of Fresh Creek, Dover

C5	43°11′44″N, 70°50′13″W	14	Fresh Creek at Rte. 101 Bridge (Gulf Road), Dover
C6	43°11′25″N, 70°50′34″W	13.7	East bank, just upstream from Fresh Creek, Dover
C7	43°11′21″N, 70°50′48″W	13.9	East of McKone Road Landing, just downstream from lower narrows, Dover
C8	43°11′30″N, 70°51′01″W	14.05	Lower narrows on west bank near marsh from McKone Road Landing, Dover
C9	43°11′30″N, 70°51′11″W	14.25	Upstream from lower narrows, northeast of McKone Road Landing, Dover
C10	43°11′38″N, 70°51′11″W	14.4	East bank just east of Cocheco Country Club, opposite McKone's Marsh, Dover
C11	43°11′44″N, 70°51′26″W	14.6	East bank, west of Cocheco Country Club and just upstream from the mouth of Emerson Brook, Dover
C12	43°11′46″N, 70°51′48″W	14.7	East bank near Dover Sewage Treatment Plant and red brick factory, Dover
C13	43°11′50″N, 70°51′52″W	14.9	East of red brick factory, near cemetery at Cocheco Street, east bank, Dover
C14	43°11′47″N, 70°51′58″W	15	East of Dover sewage treatment plant, west bank, Dover
C15	43°11′47″N, 70°52′15″W	15.4	Northeast of Old Water Street Bridge, near George's Marina and the Davis School, Dover
C16	43°11′40″N, 70°52′15″W	15.5	Between the two Water Street bridges and on west bank, Dover
C17	43°11′41″N, 70°52′22″W	15.75	Headwaters, at Central Avenue and near the fish ladder, Dover

LAMPREY RIVER
(NEW HAMPSHIRE)

Station No.	Latitude and Longitude	Miles From Coast	Description
L1	43°03′52″N, 70°54′53″W	15.8	Mouth, second promontory upstream on Shackford Point, Newmarket
L2	43°03′57″N, 70°54′49″W	15.75	Mouth, just upstream from Moody's Point on north bank, Newmarket
L3	43°04′07″N, 70°55′12″W	16.25	East bank opposite fish seines by private dock, Newmarket
L4	43°04′09″N, 70°55′20″W	16.4	Just beyond fish seine on west bank near Birch Drive, Newmarket
L5	43°04′19″N, 70°55′38″W	16.6	West bank in small cove between lower narrows and fish seines, Newmarket
L6	43°04′27″N, 70°55′39″W	16.75	East bank just south of lower narrows and opposite overhead power cables, and opposite the end of Young's Lane, Newmarket
L7	43°04′31″N, 70°55′47″W	16.85	West bank and southwest of overhead power cables and opposite the end of Young's Lane, Newmarket
L8	43°04′38″N, 70°56′06″W	17.25	Upper narrows, east bank, Newmarket
L9	43°04′50″N, 70°56′01″W	17.5	Headwater, near dam to Sewage Treatment Plant and at Rte. 108, Newmarket

OYSTER RIVER
(NEW HAMPSHIRE)

Station No.	Latitude and Longitude	Miles From Coast	Description
O1	43°07′23″N, 70°52′20″W	11.5	Mouth, northwest tip of Durham Point and just north of Langley Road, Durham
O2	43°07′29″N, 70°52′17″W	11.5	Mouth, Emerson's Beach, pier area and red boat house, opposite from Durham Point, Durham

O3	43°07′32″N, 70°52′53″W	11.95	Large private dock, north of Mathes Farm Road, Durham
O4	43°07′42″N, 70°52′36″W	11.8	Smith Creek, mouth, Durham
O5	43°07′43″N, 70°52′58″W	12.25	Midway between Smith and Bunker Creeks on the Rte. 4 side, Durham
O6	43°07′58″N, 70°53′10″W	12.5	Mouth, Bunker Creek, Durham
O7	43°07′52″N, 70°53′50″W	13	Directly across from the mouth of Johnson Creek, Durham
O8	43°07′59″N, 70°53′48″W	13	Mouth, Johnson Creek, near Riverview Court ending, Durham
O9	43°08′14″N, 70°54′00″W	13.45	Johnson Creek Bridge at Rte. 4, Durham
O10	43°07′59″N, 70°54′16″W	13.35	Mouth, Horsehide Brook, Durham
O11	43°08′12″N, 70°54′27″W	13.6	Just upstream of Durham Waste Treatment Plant, Durham
O12	43°08′05″N, 70°54′40″W	13.75	Opposite Jackson's Landing, Durham
O13	43°08′05″N, 70°54′48″W	13.90	Mouth, Beards Creek, Durham
O14	43°07′52″N, 70°55′06″W	14.2	Headwater at Rte. 108, along Old Landing Road, Durham

SALMON FALLS RIVER
(New Hampshire/Maine)

Station No.	Latitude and Longitude	Miles From Coast	Description
SF1	43°10′48″N, 70°49′40″W	12.5	Mouth, on east bank of peninsula separating Piscataqua River from Salmon Falls River, Dover, N.H.
SF2	43°10′37″N, 70°49′26″W	12.6	Mouth, east bank, South Berwick, Maine
SF3	43°10′52″N, 70°49′16″W	12.7	First brook on Salmon Falls River, mouth, South Berwick, Maine
SF4	43°10′53″N, 70°49′41″W	12.8	West side, opposite the mouth of the first brook (or SF3), Dover, New Hampshire
SF5	43°11′18″N, 70°49′38″W	13.25	East bank, just south of Rte. 101 (Eliot) bridge, South Berwick, Maine

Salmon Falls River (NH) (Cont.)

Station No.	Latitude and Longitude	Miles From Coast	Description
SF6	43°11′23″N, 70°49′48″W	13.3	West bank, opposite and somewhat south of Rte. 101 (Eliot) Bridge, Dover, New Hampshire
SF7	43°11′24″N, 70°49′30″W	13.5	East side at Rte. 101 (Eliot) Bridge, South Berwick, Maine
SF8	43°11′25″N, 70°49′20″W	13.8	Just upstream from Rte. 101 (Eliot) Bridge, east bank at end of Waterside Lane, South Berwick, Maine
SF9	43°11′40″N, 70°48′59″W	14	East bank, by cemetery, near Rte. 101 (Eliot) Bridge, South Berwick, Maine
SF10	43°11′50″N, 70°49′06″W	14.2	Above SF9, approximately 1/3 the distance between Rte. 101 (Eliot) Bridge and Hamilton House, South Berwick, Maine
SF11	42°59′47″N, 70°56′20″W	14.8	Mouth, Sligo Brook, Rollinsford, New Hampshire
SF12	42°59′43″N, 70°51′20″W	15.2	Hamilton House near mouth of Hamilton Brook, South Berwick, Maine
SF13	43°11′59″N, 70°49′11″W	15.75	East bank, just below Leigh's Mill Pond, South Berwick, Maine
SF14	43°12′01″N, 70°49′23″W	15.75	West bank near Sligo Road and opposite SF13, Rollinsford, New Hampshire
SF15	42°51′03″N, 70°57′00″W	16.3	East bank just above Leigh's Mill Pond, South Berwick, Maine
SF16	42°58′51″N, 70°56′43″W	16.5	Headwater at Portland Avenue Bridge, east and west banks, South Berwick, Maine

SQUAMSCOTT RIVER
(NEW HAMPSHIRE)

Station No.	Latitude and Longitude	Miles From Coast	Description
S1	43°03′09″N, 70°54′47″W	16.2	Mouth, on west bank at railroad bridge, Newfields
S2	43°02′59″N, 70°55′03″W	16.5	West bank near creek and just upstream from railroad bridge, Newfields
S3	43°02′51″N, 70°55′02″W	16.7	West bank, just upstream of S2 and midway between towers and Rte. 108 Bridge, Newfields
S4	43°02′33″N, 70°55′09″W	16.9	East bank at towers for overhead power cable, Stratham
S5	43°02′24″N, 70°55′43″W	17.45	Bridge at Rte. 108, Chapman's Landing, Newfields
S6	43°02′01″N, 70°56′13″W	18	East bank, upstream of Chapman's Landing and 1/4 of the way between S5 and S9, Newfields
S7	43°01′35″N, 70°56′04″W	18.55	East bank, halfway between S5 and S9, Stratham
S8	43°01′11″N, 70°55′57″W	19.2	East bank near private dock and three quarters of the way between S5 and S9, Stratham
S9	43°00′46″N, 70°56′23″W	19.75	West bank by railroad track, near overhead power lines (towers), Exeter
S10	43°00′01″N, 70°56′24″W	20.75	West bank, just upstream of oxbow cut and just north of Rte. 101 fixed bridge, Exeter
S11	42°59′48″N, 70°56′19″W	21	Opposite the mouth of Wheelwright Creek, Exeter
S12	42°59′43″N, 70°56′20″W	21.2	East bank, just upstream from the mouth of Wheelwright Creek, Exeter
S13	42°59′31″N, 70°56′42″W	21.5	West bank just upstream from Powell's Point, Exeter
S14	42°59′17″N, 70°57′03″W	21.9	West bank by dike and water outfall, also near the mouth of Norris Brook, Exeter

Squamscott River (NH) (Cont.)

Station No.	Latitude and Longitude	Miles From Coast	Description
S15	42°59′03″N, 70°57′01″W	22.25	Just upstream and opposite Powder-house Point, Exeter
S16	42°58′52″N, 70°56′41″W	22.7	Headwaters at tidal dam, Exeter

WINNICUT RIVER
(New Hampshire)

Station No.	Latitude and Longitude	Miles From Coast	Description
W1	43°02′47″N, 70°50′40″W	15.8	Mouth, on west bank and near the mouth of Shaw Brook, across from Portsmouth Country Club, Greenland
W2	43°02′52″N, 70°50′16″W	16.25	Mouth, on east bank and downstream from Packer's Brook, a cove area, Greenland
W3	43°02′31″N, 70°50′28″W	16.75	East bank just downstream from railroad bridge and near the end of Tide Mill Road, Greenland
W4	43°02′12″N, 70°50′55″W	17.25	Headwaters at the Rte. 101 (Portsmouth Avenue) Bridge, Greenland

HAMPTON-SEABROOK ESTUARY
(New Hampshire)
HAMPTON RIVER AND ADJACENT TRIBUTARIES

Station No.	Latitude and Longitude	Miles From Coast	Description
A-1	42°51′46″N, 70°47′02″W	1.3	At the mouth of the first major tributary SE of Tide Mill Creek on the Hampton River, Hampton

A-2	42°54′40″N, 70°49′06″W	1.91	The northeast portion of an "island" formed at the mouth of the Taylor River, Blind Creek and the upper part of Hampton River, Hampton Falls, Hampton
A-3	42°54′48″N, 70°49′40″W	1.3	Approximately 1500 feet NE of mouth of Tide Mill Creek and the Hampton River, Hampton
A-4	42°54′49″N, 70°50′04″W	2.3	Approximately 1800 feet NW of station A-2 on the Hampton River, Hampton Falls, Hampton
A-5	42°55′04″N, 70°50′32″W	3.3	Opposite a small brook, which empties into the first tributary above the mouth of Hampton Falls River, Hampton
A-6	42°55′19″N, 70°50′10″W	3.2	At the junction of the first oxbow NE of Station A-5 on the Taylor River, Hampton
A-7	42°55′34″N, 70°50′30″W	3.1	Hampton Landing on Taylor River, Hampton
A-8	42°55′12″N, 70°50′08″W	2.31	At the mouth of Nudds Canal and Blink Creek, Hampton
A-9	42°55′24″N, 70°49′08″W	2.56	Tide Mill Creek by the Route 101 bridge, Hampton
A-10	42°54′47″N, 70°51′18″W	5.2	Hampton Falls River south of Depot Avenue and near the Boston and Maine Railroad bridge, Hampton Falls
A-11	42°55′40″N, 70°50′38″W	4.4	A site approximately 2000 feet SW of the Boston and Maine sub-station, which is between Lafayette and Landing Roads. Adjacent to the Boston and Maine railroad tracks; it is on Taylor River in Hampton
A-12	42°54′39″N, 70°51′16″W	5.0	End of Depot Avenue on Hampton Falls River, Hampton Falls
A-13	42°54′58″N, 70°50′48″W	3.0	Middle of the southernmost oxbow near the mouth of Taylor River and the Hampton town line
A-14	42°55′12″N, 70°50′42″W	3.7	A bend in the first tributary above (north) of Hampton Falls River where the river crosses the

Hampton-Seabrook Est./Hampton R. & Adj. Trib. (NH) (Cont.)

Station No.	Latitude and Longitude	Miles From Coast	Description
			railroad tracks. Collections were made on the harbor side of the tracks, Hampton
A-15	42°55′12″N, 70°51′04″W	3.7	Same as A-14, except the land side of the railroad tracks, Hampton
A-16	42°55′13″N, 70°50′42″W	3.5	A salt marsh on a point of land made by the Hampton River and the first tributary above the Hampton Falls River, between stations A-5 and A-14, Hampton
A-17	42°55′20″N, 70°49′54″W	3.01	Hampton Landing, Taylor River, Hampton
A-18	42°54′34″N, 70°49′24″W	1.6	The Willows—at the mouth of Tide Mill Creek and Hampton River, Hampton

BROWN RIVER AND ADJACENT TRIBUTARIES

Station No.	Latitude and Longitude	Miles From Coast	Description
B-1	42°53′55″N, 70°49′06″W	1.0	A small "island" opposite Eastman's Slough and about 2500 feet west of the Locke Point State Park area
B-2	42°53′45″N, 70°50′14″W	1.7	Southernmost portion of Eastman Slough, near Halftide Rock and at the mouth of the Brown River, Hampton Falls-Seabrook
B-3	42°53′40″N, 70°50′40″W	1.8	Just inside the mouth of Hunt's Island Creek at the junction of Brown River (on the east side of the channel). Approximately 600 feet SW of B-2, Seabrook
B-4	42°53′59″N, 70°50′28″W	2.0	Approximately 500 feet NW of the first tributary past Hunt's Island Creek, Hampton Falls-Seabrook

B-5	42°54′11″N, 70°50′18″W	2.2	Approximately 700 feet NE of the mouth of Swain's Creek, Hampton Falls
B-6	42°54′17″N, 70°50′02″W	2.3	Robbins Point, Hampton Flats, Hampton Falls-Seabrook
B-7	42°54′16″N, 70°50′14″W	2.5	Brown's River, first tributary upstream from Swain's Creek, Hampton Falls
B-8	42°53′59″N, 70°50′18″W	2.4	Approximately 800 feet upstream from Robbin's Point, Hampton Falls-Seabrook
B-9	42°54′08″N, 70°50′24″W	2.53	Approximately 700 feet upstream from Station B-8, Hampton Falls-Seabrook
B-10	42°54′07″N, 70°50′42″W	2.8	End of Rock's Road on the Brown's River, Hampton Falls-Seabrook
B-11	42°54′23″N, 70°50′46″W	3.0	Near the mouth of the first major tributary east of the head waters of Brown's River, Hampton Falls-Seabrook
B-12	42°54′14″N, 70°51′10″W	3.3	Approximately 1500 feet upstream (west) from Station B-11, just before a major oxbow, Hampton Falls-Seabrook
B-13	42°54′26″N, 70°49′08″W	2.6	Swain's Creek, neck of first oxbow, Hampton Flats, Hampton Falls

BLACKWATER RIVER AND ADJACENT TRIBUTARIES

Station No.	Latitude and Longitude	Miles From Coast	Description
C-1	42°53′12″N, 70°49′32″W	1.5	Mouth of the Blackwater River near the first tributary SW of Mills Point, Seabrook
C-2	42°52′19″N, 70°50′28″W	2.2	Approximately 1200 feet SW of the first tributary past Riverside, Seabrook
C-3	42°52′12″N, 70°50′08″W	2.3	Approximately 1200 feet south of C-2, Seabrook

Blackwater & Adjacent Tributaries (Cont.)

Station No.	Latitude and Longitude	Miles From Coast	Description
C-4	42° 52′30″N, 70° 49′24″W	2.4	Approximately 500 feet SE of C-3, Seabrook
C-5	42° 52′55″N, 70° 49′34″W	2.5	Approximately 800 feet SE of C-4, Seabrook
C-6	42° 52′32″N, 70° 49′18″W	2.7	Approximately 800 feet SE of C-5, near the first major tributary SE of C-2, Seabrook
C-7	42° 52′28″N, 70° 49′12″W	3.0	Approximately 1200 feet SE of C-6 near a large white rock
C-8	42° 52′21″N, 70° 49′08″W	3.3	Approximately 1500 feet SE of C-7, Seabrook
C-9	42° 52′12″N, 70° 49′02″W	3.6	By the route 268 bridge that crosses the Blackwater River, Seabrook
C-10	42° 53′10″N, 70° 49′24″W	1.3	Mill's Point at the mouth of Blackwater River, Seabrook
C-11	42° 53′02″N, 70° 49′44″W	1.7	Riverside, Seabrook

KNOWLES ISLAND AND MILL CREEK AREAS

Station No.	Latitude and Longitude	Miles From Coast	Description
D-1	42° 53′42″N, 70° 49′52″W	1.34	Mouth of Creek, between Knowles Island and mainland, Seabrook
D-2	42° 53′42″N, 70° 50′22″W	1.6	Before the first bend, near D-1, Seabrook
D-3	42° 53′45″N, 70° 50′34″W	2.1	Walton Landing at the end of Walton Road, Seabrook

HAMPTON HARBOR
(NEW HAMPSHIRE)

Station No.	Latitude and Longitude	Miles From Coast	Description
H-1	42°53′40″N, 70°49′18″W	0.4	Hampton Harbor at the junction of the middle piling of the tall bridge and the tower at Hampton
H-2	42°53′20″N, 70°49′24″W	1.0	Hampton Harbor, in the channel near the mouth of the Blackwater River and at the junction of the imaginary line between Seabrook Marina and Knowles Island, Hampton
H-3	42°53′55″N, 70°48′58″W	0.8	Hampton Harbor, Smith and Gilmore Marina, Hampton
H-4	42°54′05″N, 70°49′12″W	0.97	Hampton Harbor, Hampton Marina at the mouth of Hampton River, Hampton. The station was the point protruding into the harbor proper.