Sci. Rep. Kanazawa Univ.
Vol. 34 No. 1 pp. 1～57
June 1989

Late Cenozoic Elasmobranchs from the Hokuriku district, central Japan

Hiroaki KARASAWA*

Department of Earth Sciences, Faculty of Science, Kanazawa University

Abstract A total of 24 species distributed among 18 genera of elasmobranchs are systematically described from the Miocene formations and the Pleistocene Zukawa Formation in the Hokuriku District. Besides one species *Scyliorhinus kasenoi* new to science, they consist of *Hexanchus gigas, Dalatias licha, Squalus* cfr. *serriculus, Pristiophorus* sp., Rajidae, gen. et sp. indet., *Rhinoptera* sp., *Squatina* sp., *Eugomphodus acutissima, E. cuspidatus, Odontaspis volax, Alopias superciliosus, Cetorhinus maximus, Carcharocles megalodon, Parotodus benedeni, Isurus desori, I. hastalis, I. planus, I. oxyrhinchus, Carcharodon carcharias, Hemipristis serra, Galeocerdo aduncus, Carcharhinus egertoni, C. priscus, C. acanthodon,* and Carcharhinidae, gen. et sp. indet.

Seven elasmobranch assemblages chronologically distinct are recognized and the late Cenozoic paleoenvironment is inferred based on the assemblages (Table 6).

Introduction

In the Hokuriku district, Ishiwara (1921) first described some fossil elasmobranch teeth from the Miocene deposits in the Noto Peninsula. After that, elasmobranch fossils were reported by Kamei (1969), Nishimoto *et al.* (1980), Goto and Akabane (1982), Karasawa (1983), Matsuura *et al.* (1984), Nakagawa and Yasuno (1985), Matsuura and Horita (1986), Goto and Goto (1987) and Kuga and Nomura (1987).

Recently the writer could obtain about one thousand specimens of the elasmobranch teeth, vertebrae and rostral teeth from the Miocene formations as the Wajimazaki Formation, the Andaibara Formation, the Sekinobana Formation, the Higashi-innai Formation, the Maenami Formation, the Hannoura Formation, the Suso Formation, the Izumo Member of the Horimatsu Formation, the Takakubo Formation, the Kurahara Formation and the Kinjosan Formation, and the Pleistocene Zukawa Formation in the Hokuriku district. This paper deals with the description and stratigraphic distribution of the Neogene elasmobranchs of the Hokuriku district. 24 species among 18 genera are systematically described. A new species, *Scyliorhinus kasenoi,* ("Cat Shark") is described on the basis of teeth materials from the Suso Formation. A tooth of the basking shark *Cetorhinus* is found from the Maenami Formation, which is the first record of the fossil

*Present address : Department of Earth Sciences, School of Science, Nagoya University, Nagoya 464, Japan.

tooth from the Japanese Miocene formations.

Seven elasmobranch assemblages characterized by the association of several dominant genera are recognized. On the basis of the stratigraphic distribution of the assemblages, the Late Cenozoic sequence in the district is divided into 6 zonules. The paleoenvironment indicated by each elasmobranch assemblage is inferred, referring to the geographical and the bathymetric distributions of the recent genera.

The described specimens are reposited at the Department of Earth Sciences, Faculty of Science, Kanazawa University.

Acknowledgments

The writer wishes to express his hearty thanks to Professor Emeritus Yoshio Kaseno of the Kanazawa University, Professor Junji Itoigawa and Associate Professor Tomowo Ozawa of the Nagoya University, and Dr. Keiji Matsuoka of the Toyohashi Museum of Natural History who gave useful suggestion and critical reading of the manuscript.

The writer is also much indebted to the following persons for their kind help at various stages of this study : Mr. Hiroyuki Nishimoto of the Tajimi-kita High School, Dr. Nobuomi Matsuura of the Kanazawa-Izumigaoka High School, Mr. Susumu Tomida of the Chukyo Junior College, Mr. Yoshitsugu Okumura of the Mizunami Fossil Museum, Mr. Atsushi Ujihara and Mr. Hisanori Wakamatsu of the Nagoya University, Mr. Masazumi Nomura of the Sannou Elementary School, Mr. Hiroaki Shimokawa and Mr. Hideki Yamamoto of the Kanazawa University, Mr. Hideo Komatsu of Kanazawa City in Ishikawa Prefecture.

Geologic and Stratigraphic Setting

The Late Cenozoic deposits are well developed in Toyama and Ishikawa Prefectures. They carry rich and varied marine invertebrate and vertebrate faunas. As to the stratigraphic classification of the Hokuriku district, the readers can refer to Kaseno (1965 and 1977). Materials of fossil elasmobranchs on which this paper is based were obtained from the following 14 localities (Figure 1).

Locality 1.

Location : Coast of Kamogaura, Wajimazaki-machi, Wajima City [37° 24′ 15″N, 136° 54′E] .

Lithology, stratigraphic position and geologic age : Fine-grained calcareous sandstone and medium-grained sandstone of the Middle Miocene Wajimazaki Formation, CN5a of Calcareous Nannoplankton Zone by Okada and Bukry (Kami *et al.*, 1981).

Elasmobranch species : *Dalatias licha, Squalus* cfr. *serriculus.*, Rajidae, gen. et sp. indet., *Eugomphodus acutissima, Odontaspis volax, Carcharocles megalodon, Parotodus benedeni, Isurus desori, I. hastalis, I. planus, Carcharhinus egertoni, C. priscus.*

Associated fauna : foraminifers-*Bolivina* cfr. *robusta, Cassidulina subglobosa, Cibicides* spp. ; molluscs

-*Fissidentalium yokokamai, Gloripallium crassivenium, Lucinoma acutilineatum* : Echinoids-*Linthia* sp.

Locality 2.

Location : Andaibara, Monzen-machi, Fugeshi-gun [37° 19′N, 136° 47′N] .

Lithology, stratigraphic and geologic age : Fine-grained calcareous sandstone of the Middle Miocene Andaibara Formation, CN5a of Calcareous Nannoplankton Zone by Okada and Bukry (Kami *et al.*, 1981).

Elasmobranch species : *Isurus hastalis, I. planus.*

Associated fauna : foraminifers-*Cassidulina subglobosa, Cibicides* spp. ; molluscs-*Fissidentalium yokoyamai, Gloripallium crassivenium, Lucinoma acutilineatum.*

Locality 3.

Location : Sekinobana, Togi-machi, Hakui-gun [37° 12′ 40″N, 136° 41′ 30″E] .

Lithology, stratigraphic position and geologic age : Pebbly conglomerate, coarse-grained sandstone, coquina and fine to medium-grained sandstone of the Middle Miocene Sekinobana Formation, CN4 to CN5a of Calcareous Nannoplankton Zone by Okada and Bukry (Kami et al., 1981).

Elasmobranch species : *Hexanchus gigas, Dalatias licha, Pristiophorus* sp., *Rhinoptera* sp., *Squatina* sp., *Eugomphodus acutissima, E. cuspidatus, Odontaspis volax, Alopias superciliosus, Carcharocles megalodon, Isurus desori, I. hastalis, I. planus, Hemipristis serra, Galeocerdo aduncus, Carcharhinus egertoni, C. priscus, C. acanthodon.*

Associated fauna : foraminifers-*Buccella tanai, Cassidulina margareta, Cibicides* spp., *Globigerina spp.* ; molluscs-*Ostrea* sp., *Chlamys* sp., *Fissidentalium yokoyamai, Gloripallium crassivenium, Lucinoma acutilineatum* ; echinoids-*Linthia* sp. ; mammals-*Paleoparadoxia* sp.

Locality 4.

Location : Kadoshima, Noto-machi, Fugeshi-gun [37° 17′ 20″N, 137° 8′E] .

Lithology, stratigraphic position and geologic age : Coarse-grained sandstone of the Early Middle Miocene Higashi-innai Formation, N. 8 of Blow's scale.

Elasmobranch species : *Squalus* cfr. *serriculus, Eugomphodus acutissima, Carcharhinus egertoni, C. priscus.*

Associated fauna : molluscs-*Ostrea* sp. ; osteichtyes-*Diodon* sp.

Locality 5.

Location : Maenami, Anamizu-machi, Fugeshi-gun [37° 12′ 45″N, 137° 4′ 10″E] .

Lithology, stratigraphic position and geologic age : Fine-grained calcareous sandstone and pebbly conglomerate of the Middle Miocene Maenami Formation.

Elasmobranch species : *Eugomphodus acutissima, E. cuspidatus, Odontaspis volax, Cetorhinus maximus, Carcharocles megalodon, Isurus desori, I. hastalis, I. planus, Carcharhinus priscus, C. acanthodon.*

Associated fauna : molluscs-*Kotorapecten kagamianus* ; mammals-*Paleoparadoxia* sp.

Locality 6.

Location : Hannoura, Notojima-machi, Kashima-gun [37° 6′ 20″N, 137° 56′ 45″E] .

Lithology, stratigraphic position and geologic age : conglomerate of the Middle Miocene Hannoura Formation.

Elasmobranch species : *Hexanchus gigas, Eugomphodus cuspidatus, Carcharocles megalodon, Isurus desori, I. hastalis, I. planus, Carcharhinus priscus, C. egertoni.*

Associated fauna : mammals-*Paleoparadoxia tabatai, Mesoplodon* sp.

Locality 7.

Location : Hannoura, Notojima-machi, Kashima-gun [37° 7′N, 136° 56′ 50″E] .

Lithology, stratigraphic position and geologic age : Fine-grained sandstone of the Middle Miocene

Suso Formation.

Elasmobranch species : *Hexanchus gigas, Squalus* cfr. *serriculus, Pristiophorus* sp., *Squatina* sp., *Eugomphodus cuspidatus, Carcharocles megalodon, Parotodus benedeni, Isurus desori, I. hastalis, I. planus, Scyliorhinus kasenoi* sp. nov., *Carcharhinus egertoni, C. priscus.*

Associated fauna : sponges-*Aphrocallistes* sp.

Locality 8.

Location : Hiuchidani, Shika-machi, Hakui-gun [37° 27′N, 136° 48′ 45″E] .

Lithology, stratigraphic position and geologic age : Fine-grained standstone of the Middle Miocene Izumo Member of the Horimatsu Formation, CN5a of Calcareous Nannoplankton Zone by Okada and Bukry (Kami *et al.*, 1981).

Elasmobranch species : *Eugomphodus cuspidatus, Carcharocles megalodon, Isurus hastalis, I. planus, Scyliorhinus kasenoi, Carcharhinus priscus.*

Associated fauna : molluscs : *Gloripallium crassivenium* ; sponges-*Aphrocallistes* sp.

Locality 9.

Location : Wakihara, Kanazawa City [36° 34′ 45″N, 136° 46′ 50″E] .

Lithology, stratigraphic position and geologic age : conglomerate of the basal part of the Takakubo Formation (Late Miocene).

Elasmobranch species : *Carcharocles megalodon, Isurus hastalis, Carcharhinus priscus.*

Locality 10.

Location : Futamata, Kanazawa City [36° 33′ 40″N, 136° 46′ 35″E] .

Lithology, stratigraphic position and geologic age : conglomerate of the basal part of the Takakubo Formation (Late Miocene).

Elasmobranch species : *Carcharhinus priscus.*

Locality 11.

Location : Kurahara, Fukumitsu-machi, Nishitonami-gun [36° 35′N, 136° 50′E] .

Lithology, stratigraphic position and geologic age : andesitic sandstone of the Middle Miocene Kurahara Formation, CN5a of Calcareous Nannoplankton Zone by Okada and Bukry (Tsubouchi MS).

Elasmobranch species : *Carcharocles megalodon, Isurus hastalis, Isurus planus, Carcharhinus priscus.*

Associated fauna : molluscs-*Kotorapecten kagamianus, Mizuhopecten kimurai.*

Locality 12.

Location : Futamata-machi, Kanazawa City [36° 41′N, 136° 50′E] .

Lithology, stratigraphic position and geologic age : andesitic sandstone of the Middle Miocene Kurahara Formation, CN5a of Calcareous Nannoplankton Zone by Okada and Bukry (Tsubouchi MS).

Elasmobranch species : *Carcharocles megalodon, Isurus hastalis, Isurus planus, Carcharhinus priscus.*

Associated fauna : molluscs-*Kotorapecten kagamianus, Mizuhopecten kimurai.*

Locality 13.

Location : Kinjo-san, Daishoji-machi, Kaga City [36° 19′ 50″N, 136° 19′E] .

Lithology, stratigraphic position and geologic position : Sandstone of the Middle Miocene Daishoji Formation.

Elasmobranch species : Carcharhinidae, gen. et sp. indet.

Associated fauna : molluscs-*Anadara* cfr. *makiyamai, Chlamys hanzawae, Mizuhopecten kimurai, Cultellus izumoensis, Turritella yoshidai* (Bito *et al.*, 1979).

Locality 14.

Location : Zukawa, Takaoka City [36° 45′ 50″N, 136° 58′E] .

Lithology, stratigraphic position and geologic age : Calcareous sandstone of the Early Pleistocene Zugawa Formation.

Elasmobranch species : *Carcharodon carcharias, Isurus oxyrhinchus, Carcharhinus* spp.

Associated fauna : molluscs-*Mizuhopecten poculum, M. tokyoensis hokurikuensis.*

Elasmobranch assemblages

A total of 29 species belonging to 20 genera of the elasmobranchs have been found from the Miocene, the Pliocene and the Pleistocene formations in the Hokuriku district (Table 1). The species list in Table 1 was prepered from the results of the present as well as 14 localities cited from the previous works are chronologically arraged as follows.

1. Miocene.

Locality 15 ; Okuma, Uozu City. The Kurosedani Formation (Goto and Akahane, 1982).

Locality 16 ; Osawano-machi, Kaminikawa-gun. The Kurosedani Formation (Itoigawa *et al.*, 1985).

Locality 17 ; Osawano-machi, Kaminiikawa-gun. The Higashibessho Formation (Nishimoto *et al.*, 1980).

Locality 18 ; Osawano-machi, Kaminiikawa-gun. The Otogawa Formation (Itoigawa *et al.*, 1985).

Locality 19 ; Yokoyama, Suzu City. The Najimi Formation (Kamei, 1969).

Locality 20 ; Iori, Iori-machi, Nanao City. The Iori Formation (Matsuura and Horita, 1986).

Locality 21 ; Iwaya, Nanao City. The Nanao Member of the Akaura Formation (Kuga and Nomura, 1987).

Locality 22 ; Kanazu-machi, Sakai-gun. The Hosokubo Formation (Nakagawa and Yasuno, 1985).

2. Pliocene.

Locality 23 ; Sobogaura, Notojima-machi, Kashima-gun. The Nozaki Formation (Fuji, 1982).

Locality 24 ; Akasaki, Ota-machi, Nanao City. The Akasaki Formation (Matsuura and Horita, 1986).

3. Pleistocene.

Locality 25 ; Suginoya, Shio-machi, Hakui-gun. The Suginoya Formation (Matsuura and Horita, 1984).

Locality 26 ; Maki-machi, Kanazawa City. The Omma Formation (Matsuura *et al.*, 1984).

Locality 27 ; Yakata-machi, Kanazawa City. The Omma Formation (Matsuura *et al.*, 1984).

Locality 28 ; Higashinagae, Kanazawa City. The Omma Formation (Matsuura *et al.*,

1984).

Elasmobranch assemblage from each formation is characterized by several dominant genera and also by some subdominant ones. The seven elasmobranch assemblages which are shown in Table 3 can be discriminated in the Late Cenozoic beds of the Hokuriku district. On the basis of the stratigraphic ranges of the shark assemblages mentioned above (Table 2 and 3), it is possible to distinguish 6 zonules in the late Cenozoic marine sediments in the Hokuriku district. As is clearly shown in Table 4, association of elasmobranch species changes at every stratigraphic horizons. Association of species in each assemblage and the relative abundance in the frequency of occurrence is summarized in Table 4.

The change in the association of species took place at horizons approximately at about 15 and 13 Ma in the Miocene age. The elasmobranch fauna existed prior to 15 Ma is dominated by species of *Carcharhinus,* the faunas from 15 to 13.4 Ma contain species of *Isurus* and *Eugomphodus* as dominant elements in addition to the species of *Carcharhinus,* and the fauna after 11 Ma is dominated by *Carcharhinus.* Therefore, two transformations of elasmobranch faunas are clearly recognized in 15 Ma and between 13.4 and 11-5 Ma. As far as the elasmobranch fauna in the district is concerned, no fossil records have been known in the interval from 13.4 to 11 Ma and 5 to 3 Ma.

Paleoenvironments

Table 5 shows the climatic and the bathymetric distributions, and the mode of life of the living shark genera. The paleoenvironments and paleoecology of the Neogene and the Quaternary elasmobranch assemblages can be inferred, referring to the climatic and bathymetric distributions of the recent elasmobranchs (Table 6).

1. *Carcharhinus*-(*Eugomphodus*) assemblage.

Carcharhinus and *Eugomphodus* are neritic sharks dwelling in the tropical to subtropical seas. This fauna does not include only epipelagic forms. On the basis of the elasmobranch fauna, tropical to subtropical shallow sea environments can be inferred. Especially, the fauna of the Kurosedani Formation (Itoigawa *et al.,* 1985) contains *Aetobatis* and *Rhinoptera* which are the dwellers in the tropical shallow seas.

2. *Isurus*-*Carcharhinus*-*Eugomphodus* assemblage.

This assemblage is mainly composed of neritic to epipelagic nektons in the tropical to subtropical seas. An epipelagic nekton, *Isurus* is predominated. The assemblage contains *Hemipristis* and *Rhinoptera* which are distributed in the tropical regions. The frequency of these is, however, very low. The environment inferred by the elasmobranch assemblage is subtropical to temperate shallow seas influenced by epipelagic waters having high sea-water temperature in the upper layer.

3. *Isurus*-*Carcharhinus* assemblage.

Generic composition of this assemblage is similar to that of the former fauna but this

does not contain *Eugomphodus* as a dominant element. Among species, the frequency of nekton forms dwelling in epipelagic to mesopelagic seas is very high. On the contrary, the frequency of benthic forms in shallow seas are found relatively very low. Except for *Hemipristis,* an element of tropical environment, the genera of tropical to temperate seas increase as compared with the former assemblage. Judging for these ecological data, the assemblage may indicate neritic to epipelagic environment under warm sea-water temperature.

4. *Carcharhinus-Eugomphodus-Isurus* assemblage.

The generic composition is similar to that of the former assemblage. The frequency of epipelagic to mesopelagic forms is very high. There are no genera which are characteristic to shallow seas and tropical seas. This assemblage indicates neritic to epipelagic environment having warm sea-water temperature.

5. *Carcharhinus* assemblage.

This represents shallow sea environment with warm water temperature.

6. *Carcharodon* assemblage.

This assemblage is dominated by *Carcharodon,* a neritic to epipelagic dweller having worldwide distributions. Therefore, this assemblage may reflect the neritic to epipelagic environment.

7. *Carcharodon-Carcharhinus* assemblage.

This assemblage as well as the former assemblage indicates neritic to epipelagic environment.

Systematic Description

Class Chondorichytes

Subclass Elasmobranchii

Superorder Squalomorphii

Order Hexanchiformis

Family Hexanchidae

Genus Hexanchus Rafinesque, 1810

Type species : *Squalus griseus* Bonnaterre, 1780

Geologic range : Jurassic-Recent.

Hexanchus gigas (Sismonda, 1861)

(Plate I , Figure 1)

1861 *Notidanus gigas* Sismonda, p. 460, pl. 1, fig. 13.

1907 *Heptranchias andersoni* Jordan, p. 101, fig. 3.

1969 *Notidanus primigenius* Agassiz : Menesini, p. 9, pl. 1, figs. 1-6.

1983 *Hexanchus* sp. : Uyeno *et al,* p. 29, pl. 1, figs. a-1.

1984 *Hexanchus* sp. A : Uyeno *et al.,* p. 136, pl. 1, figs. 1-4, 7-9.

1985 *Hexanchus* sp. 1 : Itoigawa *et al.,* p. 26, pl. 4, figs. 4-19.

1985 *Hexanchus* sp. 2 : Itoigawa *et al.,* p. 27, pl. 3, fig. 22 ; pl. 4, figs. 20-24.

Materials : Three upper teeth specimens (KUE1645-1647) from Loc. 3 ; one lower tooth specimen (KUE0001) from Loc. 6.

Diagnosis : Teeth morphology much different between upper and lower jaws ; upper teeth with primary cusp, followed by one to a few small lateral cusplets on distal side ; lower teeth with primary cusp possessing serrations at mesial side and many lateral cusplets on distal side ; roots rectangular, wide and thin.

Descriptions : Upper teeth (KUE1645-1647) remain only primary cusps ; crowns with weak cutting edge slender, elongate and conical. Lower tooth (KUE0001) possess primary cusp and two lateral cusplets on distal part ; crown with sharp cutting edge ; crown bears primary cusp with fine serrations at mesial direction ; mesial and distal margins nearly straight ; labial face slightly convex and lingual face moderately convex ; root rectangular and thin.

Remarks : *Heptranchias andersoni* Jordan from the Miocene Formation of North America (Jordan, 1907) has thick crown with fine serrations on the mesial margin of a main cusp. The characters of the species quite coincide with ones of *H. gigas*. Therefore, *H. andersoni* are considered to be synonymous with *H. gigas*. *Notidanus primigenius* from the Miocene Formation in Italy (Menesini, 1969) has the primary cusp with fine serrations on the mesial side. Thus, this species does not belongs to *N. primigenius* but is included in *H. gigas*.

H. sp. A from the Oligocene Ashiya Group (Uyeno *et al.*, 1984), *H.* sp. 1 and *H.* sp. 2 from the Miocene Mizunami Group (Itoigawa *et al.*, 1985), and *H.* sp. from the Miocene Chichibumachi Group (Uyeno *et al.*, 1983) are identical with *H. gigas* on the basis of teeth characters.

Occurrence : The species is known to occur in the Miocene formations as the Hannoura Formation, the Suso Formation and the Sekinobana Formation.

Order Squaliformis

Family Dalatidae

Genus *Dalatias* Rafinesque, 1810

Type species : *Squalus licha* Bonnaterre, 1788

Geologic range : Eocene-Recent.

Dalatias licha (Bonnaterre, 1788)

(Plate I , Figure 2)

1788 *Squalus licha* Bonnaterre, p. 12.

1977 *Scymnorhinus licha* (Bonnaterre) : Landini, p. 120, pl. 1, figs. 24-34.

1983 *Dalatias* sp. Karasawa, p. 188, pl. 53, fig. 7.

1984 *Dalatias licha* (Bonnaterre) : Keyes, p. 209, figs. 21-28.

1985 *Dalatias licha* (Bonnaterre) : Itoigawa *et al.*, p. 44, pl. 21, figs. 24-29.

Materials : One lower tooth specimen (KUE0057) from Loc. 3.

Diagnosis : Teeth morphology much different between upper and lower jaws ; upper

teeth small, needle-shaped ; lower teeth large, bladelike, triangular and bear fine serrations ; roots rectangular and have medium labial hollow.

Descriptions : Lower tooth (KUE0057) lacks root ; crown with serrated cutting edge, small, acute triangular, wide and thin ; mesial and distal margins slightly concave ; labial face nearly flat and lingual face slightly convex.

Remarks : *Dalatias* sp. from the Miocene Wajimazaki Formation (Karasawa, 1983) quite agrees with *D. licha* in the characters of crown.

Occurrence : The Miocene Sekinobana Formation.

Family Squalidae

Genus *Squalus* Linnaeus, 1758

Type species : *Squalus acanthias* Linnaeus, 1758

Geologic range : Cretaceous-Recent.

Squalus sp. cfr. *S serriculus* Jordan and Hannibal, 1923

(Plate I , Figures 3, 4)

Materials : One upper tooth specimen (KUE0059) and three teeth specimens (KUE1483-1485) from Loc. 4 ; one lower tooth specimen (KUE0060) and twenty fragmental teeth specimens (KUE0200-0211, 1298-1315) from Loc. 7.

Descriptions : Teeth small and very similar between jaws ; upper teeth triangular, narrower, and more upright than lower teeth ; crowns with serrated cutting edge, low, wide, and thick ; apexes of cusps strongly oblique to distal side ; mesial margins slightly convex and distal margins nearly straight ; labial faces slightly convex and lingual faces moderately convex ; bases of crowns with notches on distal direction ; bases of labial faces protruded to radical direction ; bases of labial and lingual faces of crowns with basal processes ; roots with medium labial hollow, rectangular, wide and thick.

Remarks : This species has the largest tooth among all living and fossil species of the genus *Squalus*. The characters of this species are very similar to ones of *S. serriculus* from the Miocene Formation in California (Jordan and Hannibal, 1923) by having large crowns with serrations. *Squalus* sp. 1 from the Miocene Mizunami Group (Itoigawa *et al,* 1985) has the same characters as those of *S. serriculus*. It may be identical with *S. serriculus*. *S. almeidae* Antnes and Jonet from the Miocene Formation in Europe (Antnes and Jonet, 1970), *S.* sp. 2 and *S.* sp. 3 from the Miocene Mizunami Group (Itoigawa *et al.,* 1985) have smaller teeth with no serrations. Therefore, these three species are specifically different from this *S.* cfr. *serriculus*.

Teeth of *S. serriculus* are large and bear the serrated cutting edges. These characters are quite identical with those of *Megasqualus orpiensis* (Winkler) from Upper Paleocene to Eocene in Europe. Phylogenetic relationship may exist between *S. serriculus* and *M. orpiensis*. *S.* cfr. *serriculus* occurs in the Early to early Middle Miocene deposits in Northern Pacific region, including Japan and California.

Occurrence : The Suso Formation and the Higashi-innai Formation.

Order Pristiophoriformes
Family Pristiophoridae
Genus *Pristiophorus* Muller and Henle, 1837

Type species : *Pristis cirratus* Latham, 1794
Geologic range : Cretaceous-Recent.

Pristiophorus sp.
(Plate I , Figure 5)

Materials : One rostral tooth specimen (KUE0061) from Loc. 3, three rostral teeth specimen (KUE0212 -0214) from Loc. 7.

Decriptions : Rostral teeth lack roots ; crowns slender, elongate, and thin ; apexes of cusps rounded ; mesial margins with sharp cutting edge, slightly convex and distal margins with very weak cutting edge, slightly concave ; bases of crowns rounded ; both of faces nearly flat.

Remarks : The crowns of the specimens described above have parallel margins. This character is closely related to that of *P. lineatus* from the Oligocene Poronai Group, *P.* sp. from the Miocene Mizunami Group and the living species, *P. japonicus* but in our collections imperfect specimens are available and the further discussion is difficult.

Occurrence : The Miocene Sekinobana Formation and the Miocene Suso Formation.

Superorder Batoidea
Order Rajiformes
Family Rajidae
Rajidae, gen. et sp. indet.
(Plate I , Figure 6)

Materials : One tooth specimen (KUE0063) from Loc. 1.

Descriptions : Imperfect tooth material remains only crown, very small ; occulusal face round pentagon, slightly concave ; lingual part of occulusal face protruded to lingual direction.

Remarks : As the specimen is preserved imperfectly, further discussion is difficult though the crown shows the Rajid tooth character. Two indiscriminated species of Rajidae has been reported from the Miocene Mizunami Group (Itoigawa *et al.*, 1985). In these species, the crown bears the occulusal surfaces strongly protruded to coronal direction. In this respect, the species from the Wajimazaki Formation differs from the species from the Mizunami Group.

Occurrence : The Miocene Wajimazaki Formation.

Family Rhinopteridae
Genus *Rhinoptera* Cuvier, 1829

Type species : *Myliobatis marginata* Gaint-Hilaive, 1809
Geologic range : Eocene-Recent.

Rhinoptera sp.
(Plate I, Figure 7)

Materials : Two fragmental teeth specimens (KUE0080, 1000) from Loc. 3.

Descriptions : Teeth wide and thin ; crowns wide, hexagonal and thin ; occulusal surfaces nearly flat or slightly convex ; labial and lingual faces with many striae slightly concave ; cervical bands clear and thin ; roots with parallel grooves, wide, rectangular and thin.

Remarks : Although the specimens at hand are imperfectly preserved, they exhibit diagnostic characters of the genus *Rhinoptera*. They are very similar to *R. studeri* Agassiz from the Miocene formations in Europe (Leriche, 1927 and Cappetta, 1970) and *Rhinoptera* sp. from the Miocene Formation in Italy (Menesini, 1969), and *R.* sp. from the Miocene Mizunami Group (Itoigawa *et al.*, 1985).

Occurrence : The Miocene Sekinobana Formation.

Superorder Squatinomorphii
Order Squatiniformes
Family Squatinidae
Genus *Squatina* Dumeril, 1806

Type species : *Squalus squatina* (Linnaeus, 1758)
Geologic range : Jurassic-Recent.

Squatina sp.
(Plate I, Figure 8)

Materials : One tooth specimen (KUE0400) from Loc. 3 ; three teeth specimens (KUE0062, 1288-1289) from Loc. 6 ; one tooth specimen (KUE1290) from Loc. 7.

Descriptions : Teeth lack roots, small, slender, thick, erect and elongate ; crowns having weak cutting edge ; distal and mesial margins nearly straight ; labial faces moderately convex and lingual faces strongly convex ; crown bases wide ; bases of labial faces with basal processes.

Remarks : These teeth are imperfect in preservation but coincide with the teeth of the genus *Squatina* in the characteristic of crowns. They are similar to those of well-known Miocene species, *S. subserrata* and *S.* sp. from the Miocene Mizunami Group (Itoigawa *et al.*, 1985) and it is difficult to make a clear distinction among them.

Occurrence : The Miocene Hannoura Formation.

Superorder Galeimorphii
Order Lamniformes
Family Odontaspidae

Genus *Eugomphodus* Gill, 1862

Type species : *Carcharias taurus* Rafinesque, 1810

Remarks : The genus *Odontaspis* was divided into three genera (White, 1931) ; namely, *Paradontaspis* White with type species *O. platenensis, Odontaspis* Agassiz with type species *Carcharias ferox* and *Synodontaspis* White with type species *C. taurus.* After that, it was classified that *Paradontaspis platensis,* the type species of *Paradontaspis,* was synonymous with *Synodontaspis taurus* (Gurr, 1962). Menesini (1969) and Schultz (1971) applied the divisions of White (1931) to the Miocene fossil species and they included *Odontaspis acutissima* and *O. cuspidata* in the subgenus *Synodontaspis.* Cappetta (1970) recognized two species groups in recent species of *Odontaspis,* the *O. taurus* group and *O. ferox* group. The Miocene fossil species can, also, be classified into the two species groups. He included *O. acutissima* and *O. cuspidata* in the *O. taurus* group and *O. mallosica* in the *O. ferox* group. Recently, Cappetta (1987) adapted *Synodontaspis* White as the genus. The living species, *Odontaspis taurus* and the Miocene species, *O. acutissima* and *O. cuspidata* were transferred by him from *Odontaspis* to *Synodontaspis.* According to Compagno (1984), the genus, *Odontaspis* was divided into two genera ; one is the genus *Eugomphodus* Gill with type species *Carcharias taurus* and the other is the genus *Odontaspis* Agassiz with type species *C. ferox.*

I agree with the opinion of Cappetta (1970). In my opinion, *O. acutissima* and *O. cuspidata* constitute to an evolutionary linearge of the *taurus* group and the both species can be transferred from *Odontaspis* to *Eugomphodus* which includes *Synodontaspis* as the synonym, following Compagno (1984). In the meantime, the Miocene species, *O. mallosica* and *O. volax,* were included in the *ferox* group in the genus *Odontaspis.*

Geologic range : Cretaceous-Recent.

Eugomphodus acutissima (Agassiz, 1843)

(Plate I , Figures 11, 12)

1843 *Odontaspis acutissima* Agassiz, p. 294, pl. 37a, figs. 33, 34.
1927 *Odontaspis acutissima* Agassiz : Leriche, p. 57, pl. 8, figs. 1-8.
1969 *Odontaspis* (*Synodontaspis*) *acutissima* Agassiz : Menesini, p. 10, pl. 1, figs. 7-14.
1970 *Odontaspis taurus* Rafinesque : Antnes and Jonet, p. 133, pl. 4, figs. 5-11.
1970 *Odontaspis acutissima* Agassiz : Cappetta, p. 29, pl. 2, figs. 1-16.
1983 *Odontaspis acutissima* Agassiz : Karasawa, p. 35, pl. 53, figs. 18, 19.
1983 *Odontaspis* sp. Uyeno *et al.,* p. 30, pl. 4, figs. a-i.
1985 *Odontaspis acutissima* Agassiz : Itoigawa *et al.,* p. 35, pl. 12, figs. 5, 6, 14 ; pl. 13, figs. 1-28.

Materials : Three anterior teeth specimens (KUE0024, 0025, 1716) from Loc. 1, fourteen anterior teeth specimens (KUE1676-1690) from Loc. 3 and two anterior teeth specimens (KUE1481, 1482) from Loc. 4.

Diagnosis : A species of *Eugomphodus* characterized by having striae on lingual face.

Descriptions : Teeth lacking roots, very similar between jaws, and large ; crowns with sharp cutting edge, slender, elongate, erect or oblique, and strongly reflexed in lingual side

; apexes of cusps slightly reflexed in labial side ; labial faces nearly flat and lingual faces with some fine striae, strongly convex.

Remarks : Antnes and Jonet (1970) reported the occurrence of *Odontaspis taurus* Rafinesque from the Miocene Formation in Portugal. This species is assignable to *Eugomphodus acutissima* Agassiz having the crown with striae. Case (1980) described *O. acutissima* from the Miocene Formation in Georgia but the teeth of them correspond well to *O. mallosica* by the characters of crowns that bear one or two pairs of lateral cusplets and no striae. *O.* sp. from the Oligocene Ashiya Group (Uyeno *et al.*, 1985) and *O.* sp. from the Miocene Chichibumachi Group (Uyeno *et al.*, 1983) can be identified with *Eugomphodus acutissima* by having the crowns with striae. *Eugomphodus acutissima* ranges from Oligocene (the Ashiya Group, Uyeno *et al.*, 1984) to Middle Miocene (this paper) in Japan.

Occurrence : The species occurred in the Miocene formations as the Sekinobana Formation, the Wajimazaki Formation and the Higashi-innai Formation.

Eugomphodus cuspidatus (Agassiz, 1843)
(Plate I , Figures 13-17)

1843 *Odontaspis cuspidata* Agassiz, p. 290, pl. 37, figs. 45-49.
1921 *Carcharias cuspidatus* (Agassiz) : Ishiwara, p. 10, pl. 7, figs. 12-21.
1969 *Odontaspis* (*Synodontaspis*) *cuspidata* Agassiz : Menesini, p. 13, pl. 1, figs. 15-16.
1970 *Odontaspis cuspidata* Agassiz : Cappetta, p. 32, pl. 3, figs. 6-10.
1971 *Odontaspis cuspidata cuspidata* Agassiz : Schultz, p. 319, pl. 1, fig. 6.
1974 *Carcharias obliqua* (Agassiz) : Hatai *et al.*, p. 20, pl. 2, figs. 1, 7, 10-12, 17-19.
1983 *Odontaspis* cfr. *volax* Le Hon : Karasawa, p. 188, pl. 53, figs. 12-16.
1984 *Odontaspis* sp. Uyeno and Uematsu, p. 37, pl. 5, figs. B-F.
1985 *Odontaspis* cfr. *cuspidata* Agassiz : Itoigawa *et al.*, p. 36, pl. 12, figs. 18-22.

Materials : Three anterior teeth specimens (KUE0030, 1581, 1582) from Loc. 5, two anterior teeth specimens (KUE0026, 0027), two lateral teeth specimens (KUE0028, 0029) and twenty fragmental teeth specimens from Loc. 7 ; eleven fragmental teeth specimens (KUE1666, 1692-1702) from Loc. 3, one fragmental tooth specimen (KUE1719) from Loc. 8, ten fragmental teeth specimens (KUE1247-1257) from Loc. 6.

Diagnosis : Teeth large and very similar between jaws ; crowns with sharp cutting edge, slender, and elongate ; bases of crowns bear one pair of lateral cusplets.

Descriptions : Teeth large and lack roots ; crowns with sharp cutting edge, slender, elongate and oblique, and strongly reflexed in lingual side ; apexes of cusps slightly reflexed in labial side ; bases of crowns conical and having a pair of small and wide lateral cusplets with cutting edge ; mesial and distal margins slightly concave ; lingual faces strongly convex and labial faces moderately convex ; lateral teeth with crowns wider and much thinner than anterior teeth.

Remarks : This species is distinguished from *E. acutissima* by having wide cusps with no striae. Hatai *et al.* (1974) described *Carcharias obliqua* from the Miocene Moniwa Formation and Uyeno *et al.* (1984) reported *O.* sp. from the Miocene Bonjigawa Formation.

Both species can be identified with *E. cuspidatus* in having wide crowns with no striae.

Occurrence : This species is known to occur in the Miocene formations as the Wajimazaki Formation, the Sekinobana Formation, the Maenami Formation, the Hannoura Formation, the Suso Formation and the Izumo Member of the Horimatsu Formation, and the Nanao Member of the Akaura Formation (Kuga and Nomura, 1987).

Genus *Odontaspis* Agassiz, 1843

Type species : *Carcharias ferox* Risso, 1810

Geologic range : Cretaceous-Recent.

Odontaspis volax Le Hon, 1871

(Plate I, Figures 9, 10)

1871 *Odontaspis volax* Le Hon, p. 5.

1975 *Odontaspis volax* Le Hon : Bosch *et al.*, figs. 4, 5.

1985 *Odontaspis* cfr. *volax* Le Hon : Itoigawa *et al.*, p. 36, pl. 12, figs. 7-13, 15-17.

Materials : One anterior tooth specimen (KUE0090) from Loc. 3 ; one lateral tooth specimen (KUE0091) from Loc. 3.

Diagnosis : A species of *Odontaspis* characterized by having some pairs of lateral cusplets.

Descriptions : Anterior tooth remains crown, and large ; crown with smooth cutting edge, slender, elongate, conical and erect or slightly oblique to distal side ; base of crown with no cutting edge, conical ; crown strongly reflexed in lingual direction ; apex of crown reflexed in labial direction ; mesial and distal margins slightly concave ; labial face slightly convex and lingual face strongly convex. Lateral tooth smaller and much thinner than anterior tooth ; base of crown bear two pairs of lateral cusplets.

Remarks : The crowns of *O. volax* are more thick and conical than ones of *O. mollasica.* The cutting edge of the species is weak as compared with ones of *O. mollasica.*

Occurrence : The Miocene Sekinobana Formation.

Family Alopidae

Genus *Alopias* Rafinesque, 1810

Type species : *Squalus vulupinus* Bonnaterre, 1780

Geologic range : Eocene-Recent.

Alopias superciliosus (Lowe, 1840)

(Plate II, Figure 2)

1840 *Alopecias superciliosus* Lowe, p. 18.

1958 *Alopias acutidens* Casier, p. 38, pl. 1, fig. 20.

1970 *Alopias* cfr. *supertiliosus* (Lowe) : Antnes and Jonet, p. 150, pl. 8, figs. 28, 29, 40, 41.

1980 *Alopias supertiliosus* (Lowe) : Case, p. 85, pl. 3, figs. 1-5.

Materials : One tooth specimen (KUE0032) from Loc. 3.

Diagnosis : Teeth small and very similar between jaws ; crowns with sharp cutting

edge, slender, elongate, and strongly oblique to distal side ; roots with central ridge wide.

Descriptions : Tooth small ; crown with sharp and smooth cutting edge, slender, elongate and strongly inclined to distal side ; mesial and distal margins slightly concave ; labial face moderately convex and lingual face strongly convex ; base of crown wide ; base of labial face protruded to radical direction ; cervial band clear, thin and wide ; labial face of root nearly flat and lingual face with central ridge, strongly convex ; apexes of root protruded to radical direction.

Remarks : Casier (1958) described *A. acutidens* with slender and elongate crown inclined to the distal direction from the Miocene Bissex Hill Formation in Barbados. In the characters, it is quite identical with the living species, *A. superciliosus*. Therefore, *A. acutidens* can be synonymous with *A. superciliosus*. *A. superciliosus* has been reported from the Miocene Formation in Portugal (Antnes and Jonet, 1970), America (Case, 1980), Barbados (Casier, 1958) and Japan (this paper). It lives in the present-day oceans.

Occurrence : The Miocene Sekinobana Formation.

Family Cetorhinidae

Genus *Cetorhinus* Blainville, 1816

Type species : *Squalus maximus* Gunner, 1765

Remarks : *Cetorhinus maximus,* a living species of the Genus *Cetorhinus* is a plankton feeder in epipelagic waters of worldwide distributions. Leriche (1908) described the gill raker's fossil, *C. parvus* from the Oligocene Formation in Europe. After that, the teeth of this species have been known from the Oligocene to Miocene formations in Europe (Herman, 1979 and Bosch, 1984).

Bosch (1984) recently rexaminated the living and the fossil *Cetorhinus*. He recognized two unnamed living species (*Cetorhinus* sp. 1 and *C.* sp. 2) and one unnamed Pliocene to Miocene species (*C.* sp. 3), and indicated that *C. parvus* may belong to the other genus. Certainly, two living species figured by him can be distinguished each other in the teeth characters and the gill raker's dimensions. However, these difference in the teeth and gill raker's dimension may merely represent variations caused by the stage at the step of growth because the growth ratio between body length and the teeth dimension significantly varies ontogenetically. Therefore, the writer does not agree with the opinion of Bosch (1984) and includes *C. maximus* in *Cetorhinus*. In addition to this, *C. parvus* can also be included in *Cetorhinus* as stated by Cappetta (1987).

Cetorhinus is known to occur from the Oligocene and the later deposits. *C. parvus* occurs in the Oligocene and Miocene deposits and *C. maximus* from the Miocene to Recent.

Geologic range : Oligocene-Recent.

Cetorhinus maximus (Gunner, 1765)

(Plate II, Figure 1)

1765 *Squalus maximus* Gunner, p. 33.

1974 *Cetorhinus maximus* (Gunner) : Herman *et al.* : p. 23, pl. 1, fig. 7.
1977 *Cetorhinus maximus* (Gunner) : Landini, p. 111, pl. 7, figs. 18, 19.
1984 *Cetorhinus* sp. type 3, Bosch, p. 214, figs. 23-39.

Materials : One tooth specimen (KUE0033) from the Maenami Formation at Loc. 4.

Diagnosis : Teeth small and very similar between jaws ; crowns with sharp cutting edge, hocklike ; labial face with fine striae.

Descriptions : Tooth imperfectly preserved and small ; crown with sharp cutting edge, triangular, wide, thick, and reflexed strongly in lingual direction ; apex of crown oblique to distal side ; mesial margin strongly convex and distal margin gently concave ; labial face with many fine striae gently convex and lingual face moderately convex ; base of crown with no cutting edge and rounded ; remaining root wide, thin, high and conical.

Remarks : The fossil tooth of the genus *Cetorhinus* is the first record from the Japanese Miocene formations. It is identified with the living species, *Cetorhinus maximus* in having the above-mentioned characters. It differs from the fossil species, *C. parvus* by having slender crown and the wide root. *Cetorhinus* sp. 3 illustrated by Bosch (1984) from the Early Pliocene to Middle Miocene formations in Europe has similar characters and can be identified with *C. maximus*. *C. maximus* appears at the Miocene time although Cappetta (1987) indicated that *C. maximus* occurred the Pliocene deposits.

Occurrence : The Miocene Raenami Formation.

Family Otodontidae

Genus *Carcharocles* Jordan and Hannibal, 1923

Type species : *Carcharodon auliculatus* Blainville, 1818

Remarks : Casier (1960) divided the genus *Carcharodon* into the three genera, *Palaeocarcharodon, Procarcharodon* and *Carcharodon*. Based on tooth morphology, he considered that each genus constitutes an evolutionary lineage ; *Paleocarcharodon* was differentiated from *Cretolamna appendiculata* during the Paleocene time ; *Procarcharodon* was derived from *Otodus obliqua subserata* during the Eocene time, and *Carcharodon* from *Isurus estheri* during the Miocene time. According to Cappetta (1987), *Procarchardon* with type species *Carcharodon angustidens* is the subjective synonym with *Carcharocles* with type *Carcharodon auliculatus*. In this paper, the writer follows the opinion of Cappetta (1987) and used the genus *Carcharocles*.

Geologic range : Paleocene-Pleistocene?.

Carcharocles megalodon (Agassiz, 1843)

(Plate IV, Figure 11 ; Plate V, Figure 1 ; Plate VI, Figure 1)

1843 *Carcharodon megalodon* Agassiz, p. 7, pl. 4, figs. 1-6 ; pl. 5, figs. 1-3.
1921 *Carcharodon megalodon* Agassiz : Ishiwara, p. 5, pl. 10, fig. 33 ; pl. 11, figs. 1-8 ; pl. 12, figs. 1, 2.
1970 *Procarcharodon megalodon* (Agassiz) : Cappetta, p. 26, pl. 6, figs. 2.
1982 *Carcharodon megalodon* Agassiz : Goto and Akahane, p. 3, pl. 1, figs. a-c.
1984 *Carcharodon megalodon* Agassiz : Uyeno and Sakamoto, p. 49, pl. 1, figs. 1-4 ; pl. 2, figs. 1-3, pl. 3,

figs. 1, 2 ; pl. 4, figs. 1-3, pl. 5, figs. 1-4. pl. 1, figs. a-c.

1987 *Carcharocles megalodon* (Agassiz) : Goto and Goto, p. 126, pl. 1, figs. 2.

Materials : One upper anterior tooth specimen (KUE0034) and one lower anterior tooth specimen (KUE0035) from Loc. 12 ; one lateral tooth specimen (KUE0095) from Loc. 9 ; two fragmental teeth specimens (KUE1677, 1642) from Loc. 3 ; one fragmental tooth specimen (KUE1709) from Loc. 1 ; one fragmental tooth specimen (KUE1286) from Loc. 7 ; one fragmental tooth specimen (KUE1287) from Loc. 6 ; one fragmental tooth specimen (KUE1068) from Loc. 5.

Diagnosis : Teeth with no lateral cusplets, large to very large : cutting edges with serrations.

Descriptions : Upper anterior tooth (KUE0035) large and triangular ; crown with sharp cutting edge, triangular, wide, and thick ; cutting edge with serrations having 12 to 15 identiations in 10 mm distance ; labial face nearly flat ; lingual face gently convex ; mesial and distal margins gently convex ; cervical band clear and wide ; root wide and thick ; apexes of root protruded to radical direction. Lower anterior tooth (KUE0036) acute triangular and narrower than upper anterior's. Lateral tooth (KUE0095) triangular, strongly oblique, and wider than anterior tooth.

Remarks : The specimens (KUE0034, 0035) are the largest among the specimens of *C. megalodon* from Japan.

Itoigawa *et al.* (1985) reported *C. megalodon* from the Early to the early Middle Miocene Mizunami Group. Specimens from the Mizunami Group are small and a large majority of the specimens has small lateral cusplets. These teeth are morphologically similar to ones of *C. megalodon* from the Miocene Formation in Italy (Menesini, 1969 ; 1974) and *C. megalodon* var. *chubutensis* (Amegino) from the Miocene Formation in Suisse (Leriche, 1927). Recently, Cappetta (1987) regarded *C. chubutensis* teeth with lateral cusplets in the Miocene age as a variety of *C. megalodon* and discriminated *C. chubutensis* as a distinct species.

Occurrence : The species occurs in the Miocene formations as the Wajimazaki Formation, the Sekinobana Formation, the Maenami Formation, the Suso Formation, the Kurahara Formation and the Hannoura Formation.

Genus *Parotodus* Cappetta, 1980

Type species : *Oxyrhina benedeni* Le Hon, 1871

Remarks : This is a monotypic genus including only *P. benedeni*. *P. benedeni* had been included in the genus *Isurus* until recently Cappetta (1980) erected the new genus *Parotodus* with *Oxyrhina benedeni* Le Hon (1871) as the type species. *Parotodus* was probably derived from the genus *Otodus* (Cappetta, 1987). Ecologically, species of *Parotodus* seems to epipelagic dwellers because it is rarely found in the shallow deposits (Kuga, 1985 and Cappetta, 1987).

Geologic range : Miocene-Pleistocene?

Parotodus benedeni (Le Hon, 1871)

(Plate II, Figures 3-5)

1871 *Oxyrhina benedeni* Le Hon, p. 6.
1942 *Alopias grandis* Leriche, p. 73, pl. 5, figs. 21, 22.
1974 *Isurus benedeni* (Le Hon) : Menesini, p. 134, pl. 1, figs. 10-17.
1974 *Isurus moniwaensis* Hatai, Masuda and Noda, p. 19, pl. 2, figs. 20, 22.
1975 *Isurus* sp., Itoigawa *et al.*, pl. 22, fig. 11.
1977 *Isurus benedeni* (Le Hon) : Landini, p. 108, pl. 5, figs. 15-17.
1979 *Isurus* cfr. *benedeni* (Le Hon) : Nishimoto and Ujihara, p. 60, pl. 9, fig. 11.
1985 *Isurus benedeni* (Le Hon) : Itoigawa *et al.*, p. 41, pl. 20, fig. 14.
1985 *Uyenoa benedeni* (Le Hon) : Kuga, p. 14, pl. 10, fig. 3 ; pl. 11, figs. 1, 2.

Materials : Two anterior teeth specimens (KUE0036, 1608) and one lateral tooth specimen (KUE0038) from Loc. 1 ; three lateral teeth specimens (KUE0037, 1284, 1285) from Loc. 7.

Diagnosis : Teeth large and similar between jaws ; crowns with sharp cutting edge very thick ; lingual faces strongly convex and labial faces nearly flat ; both margins of anterior teeth nearly straight but laterals strongly arched.

Descriptions : Anterior teeth remain crowns and large ; crowns with sharp cutting edge, acute triangular, and markedly thick ; apexes of cusps slightly oblique to distal direction ; mesial margins nearly straight at base to central part and convex at central part of apex ; distal margins nearly straight ; labial faces slightly concave and lingual faces strongly convex. Lateral teeth large ; crowns with sharp cutting edge, triangular, and markedly thick ; apexes of cusps strongly oblique to distal side ; mesial margins strongly convex and distal margins strongly concave ; labial faces nearly flat and lingual faces strongly convex ; bases of crowns wide ; cervical band clear, wide, and thick ; root wide and thick ; apexes of roots protruded to radical direction.

Remarks : Leriche (1942) described *Alopias grandis* from the Miocene Formation in America. The teeth are wide, thick, large with arc-curved margins and these characters are identified with ones of lateral teeth of *P. benedeni*. Therefore, *A. grandis* is considered to be synonymous with *P. benedeni*. Hatai *et al.* (1974) described *I. moniwaensis* from the Miocene Moniwa Formation. The tooth of the species has the same characters as the lateral tooth of *P. benedeni* and *I. moniwaensis* is regarded as the synonym of *P. benedeni*.

Occurrence : The Miocene Wajimazaki Formation and the Miocene Suso Formation.

Family Lamnidae

Genus *Carcharodon* Smith, 1838

Type species : *Squalus carcharias* Linnaeus, 1758

Geologic range : Pliocene-Recent.

Carcharodon carcharias (Linnaeus, 1758)

(Plate IV, Figures 9, 10)

1758 *Squalus carcharias* Linnaeus, p. 235.
1843 *Carcharodon sulcidens* Agassiz, p. 259, pl. 30, figs. 3-7.

1956 *Carcharodon carcharias* (Linnaeus) : Gherardoni, p. 35, pl. 1, figs. 1-14.
1975 *Carcharodon carcharias* (Linnaeus) : Itoigawa *et al.*, p. 96, pl. 20, figs. 1-26 ; pl. 21, figs. 1-7 ; pl. 22, figs. 1-10.
1975 *Carcharodon carcharias* (Linnaeus) : Uyeno *et al.*, p. 53, pl. 5, figs. a-c.
1977 *Carcharodon carcharias* (Linnaeus) : Landini, p. 105, pl. 2, figs. 1-3.
1987 *Carcharodon carcharias* (Linnaeus) : Goto and Goto, p. 127, pl. 1, fig. 4.

Materials : Four teeth specimens (KUE0101, 0102, 0110, 0111) from Loc. 14.

Diagnosis : Teeth large and similar between jaws ; crowns with sharp cutting edge triangular ; cutting edges with very coarse serrations.

Descriptions : Teeth lack roots and large ; crowns with sharp cutting edge, wide, thin and triangular ; cutting edges bear many coarse serrations ; mesial and distal margins slightly concave ; labial faces nearly flat and lingual faces moderately convex.

Remarks : Once Ishiwara (1921) described *C. carcharias* from the Miocene Hannoura Formation but his specimen is quite identical to the lateral tooth of *Carcharocles megalodon*. Uyeno *et al.* (1975) reported the brain fossils of *C. carcharias* from the Pliocene Nobori Formation.

Occurrence : The Pleistocene Zukawa Formation.

Genus *Isurus* Rafinesque, 1810

Type species : *Isurus oxyrhinchus* Rafinesque, 1810

Geologic range : Eocene-Recent.

Isurus desori (Agassiz, 1843)
(Plate II, Figures 6-9)

1843 *Oxrhina desori* Agassiz, p. 282, pl. 37, figs. 8-13.
1970 *Isurus desori* (Agassiz) : Cappetta, p. 19, pl. 2, fig. 17.
1980 *Isurus oxyrhinchus* Rafinesque : Uyeno *et al.*, p. 127, pl. 2, figs. e, g-k.
1980 *Isurus oxyrhinchus* Rafinesque : Case, p. 82, pl. 2, figs. 4-6 (non figs. 7, 8).
1983 *?Isurus desori* (Agassiz) : Karasawa, p. 18, pl. 51, fig. 3.
1985 *Isurus desori* (Agassiz) : Itoigawa *et al.*, p. 42, pl. 17, figs. 8-10 ; pl. 18, figs. 18-23 ; pl. 19, figs. 4-16 ; pl. 20, figs. 7-9, 11.
1985 *Isurus desori* (Agassiz) : Kuga, p. 7, pl. 1, figs. 1-3 ; pl. 2, figs. 1-7 ; pl. 3, figs. 1-8.

Materials : One lower anterior tooth specimen (KUE0039), one upper first anterior tooth specimen (KUE0040), three anterior teeth specimens (KUE1532-1534) and ten lateral teeth specimens (KUE0042, 1535-1549) from Loc. 1 ; one upper second anterior tooth specimen (KUE0041), four anterior teeth specimens (KUE1635-1638) and three lateral teeth specimens (KUE1639-1641) from Loc. 3 ; two lateral teeth specimens (KUE1574, 1575) from Loc. 5 ; one lateral tooth specimen (KUE1279) from Loc. 6 ; four lateral teeth specimens (KUE1280-1283) from Loc. 7.

Diagnosis : Teeth large and similar between jaws ; crowns slender.

Descriptions : Upper first anterior tooth (KUE0040) remains crown and large ; crown with sharp cutting edge, slender, elongate, thin, and strongly inclined to distal side ; mesial margin nearly straight and distal margin gently concave at base to central part, convex at

central part to apex and concave at apex ; labial face nearly flat and lingual face moderately convex. Upper second anterior tooth lacking root, similar to first anterior's ; base of mesial margin without cutting edge, and rounded. Lower anterior tooth (KUE0039) lacks root and large ; crown with sharp cutting edge, slender, elongate, thick, and oblique to distal side ; mesial margin nearly straight and distal margin gently convex at base to central part and concave at central part to apex ; labial face nearly flat and lingual face moderately convex. Lateral teeth large ; crowns with sharp cutting edge, slender, acute triangular, thin and oblique to distal side ; mesial margins gently concave from base to central part and nearly straight from central part to apex, and distal margins nearly straight ; labial faces nearly flat and lingual faces moderately convex ; root with strong central ridge, thick and wide ; lingual face of root with central groove ; apexes of root protruded to radical direction.

Remarks : Uyeno *et al.* (1980) described *I. oxyrhinchus* from the Miocene Ichishi Group and Case (1980) reported *I. oxyrhinchus* from the Miocene Trent Formation in Georgia. The teeth specimens from the two localities mentioned above are nearly identical with those of *I. desori* in main teeth characters.

Occurrence : The species is found in the Miocene formations as the Wajimazaki Formation, the Sekinobana Formation, the Maenami Formation, the Hannoura Formation and the Suso Formation.

Isurus hastalis (Agassiz, 1843)
(Plate III, Figures 1-7)

1843 *Oxyrhina hastalis* Agassiz, p. 277, pl. 34, figs. 3-17.
1921 *Isurus hastalis* (Agassiz) : Ishiwara, p. 2, pl. 1, figs. 19-26.
1977 *Isurus hastalis* (Agassiz) : Landini, p. 107, pl. 1, figs. 4-6 ; pl. 5, fig. 18.
1983 *Isurus hastalis* (Agassiz) : Karasawa, p. 186, pl. 51, figs. 2, 9-11 ; pl. 52, figs. 3, 4, 13.
1984 *Isurus hastalis* (Agassiz) : Uyeno and Uematsu, p. 36, pl. 4, figs. h-m.
1985 *Isurus hastalis* (Agassiz) : Kuga, p. 36, pl. 5, figs. 2, 3 ; pl. 6, figs. 1-4 ; pl. 7, figs. 1-3 ; pl. 8, figs. 1-6 ; pl. 9, 1-3, 1-8.
1985 *Isurus hastalis* (Agassiz) : Itoigawa *et al.*, p. 43, pl. 17, figs. 5-7, 11-15 ; pl. 18, figs. 13-17, 15-27.

Materials : Three anterior teeth specimens (KUE0045, 1545, 1546) and two lateral teeth specimens (KUE0047, 1547) from Loc. 1 ; one lateral tooth specimen (KUE0098) from Loc. 2 ; twenty lateral teeth specimens (KUE0048, 1629-1634, 1648-1664) from Loc. 3 ; one anterior tooth specimen (KUE1568) and five lateral teeth specimens (KUE1569-1573) from Loc. 5 ; ten lateral teeth specimens (KUE0048, 1201-1209) from Loc. 6 ; one anterior tooth specimen (KUE1210) and eight lateral teeth specimens (KUE1211-1218) from Loc. 7 ; two lateral teeth specimens (KUE0041, 0047) from Loc. 9.

Diagnosis : Teeth similar between jaws and large for the genus ; crowns with sharp cutting edge which has no serrations.

Descriptions : Anterior teeth large and acute triangular ; crowns with sharp cutting edge, elongate, wide, thin, acute triangular and erect or slightly oblique to distal direction ; distal and mesial margins nearly straight ; labial faces nearly flat and lingual faces gently

convex. Crowns of lateral teeth more oblique than anterior's to distal direction ; cervical bands clear and thin ; root wide, thin and rectangular.

Remarks : *I. hastalis* commonly occurs in the Oligocene, Miocene and Pliocene deposits of the world.

Occurrence : It is commonly found in the Miocene sequences as the Wajimazaki Formation, the Andaibara Formation, the Sekinobana Formation, the Maenami Formation, the Hannoura Formation, the Suso Formation, the Izumo Member of the Horimatsu Formation, the Kurahara Formation and the Takakubo Formation.

Isurus planus (Agassiz, 1856)

(Plate III, Figures 8, 9 ; Plate IV, Figures 1-7)

1856 *Oxyrhina plana* Agassiz, p. 275.

1907 *Isurus planus* (Agassiz) : Jordan, p. 107, fig. 9.

1921 *Isurus hastalis* (Agassiz) : Ishiwara, p. 2, pl. 10, figs. 1-14.

1983 *?Isurus desori* (Agassiz) : Karasawa, p. 187, pl. 51, figs. 3, 6-8 ; pl. 52, figs. 2, 5-7, 9-14.

1984 *Isurus planus* (Agassiz) : Uyeno and Uematsu, p. 37, pl. 4, figs. N-W.

1985 *Isurus planus* (Agassiz) : Kuga, p. 9, pl. 4, figs. 1-5 ; pl. 5, fig. 1.

Materials : Twelve lateral teeth specimens (KUE0051, 1524-1531) from Loc. 1 ; one lateral tooth specimen (KUE0070) from Loc. 2 ; twenty lateral teeth specimens (KUE1609-1628, 1665) from Loc. 3 ; one anterior tooth specimen (KUE0050) and twenty lateral teeth specimens (KUE1548-1567) from Loc. 5 ; eight lateral teeth specimens (KUE0091-0093, 1219-1224) from Loc. 6 ; eight anterior teeth specimens (KUE1225-1232) and eighteen lateral teeth specimens (KUE0052-0054, KUE1233-1246) from Loc. 7 ; four lateral teeth specimens (KUE1714-1717) from Loc. 8 ; one lateral tooth specimen (KUE0052) from Loc. 11.

Diagnosis : Teeth large and similar between jaws ; crowns with cutting edge ; crowns of anterior teeth thick, and erect ; crowns of lateral teeth arched and thin.

Descriptions : Anterior teeth large ; crowns with sharp cutting edge, wide, thick, acute triangular, and reflexed in lingual direction ; apexes of cusps erect or slightly oblique to distal side ; mesial and distal margins gently concave at base to central part and nearly straight at central part to apex ; labial faces nearly flat and lingual faces moderately convex. Lateral teeth large ; crowns with sharp cutting edge, wide, thick, acute triangular and reflexed in labial direction ; apexes of cusps strongly oblique to distal side ; mesial margins strongly convex at base to central part and slightly concave at central part to apex ; distal margins strongly concave at base to central part and nearly straight at central part to apex ; labial faces slightly concave and lingual faces slightly convex ; cervical band clear and thin ; root wide, thick and rectangular.

Remarks : *Isurus planus* is similar to *Isurus hastalis* from the Early Miocene Mizunami Group (Itoigawa *et al.*, 1985). The margins of the teeth of *Isurus planus* possess more much strong curved than ones of *I. hastalis*. Therefore, the former species can be distinguished from *I. hastalis*. Ishiwara (1921) and Hatai *et al.* (1974) regarded *I. planus* as a variety of *I. hastalis*.

The distribution of this species is restricted to the Middle Miocene of the northern

Pacific region, California and Japan.

Occurrence : This species occurred in the Miocene sequences as the Wajimazaki Formation, the Andaibara Formation, the Sekinobana Formation, the Maenami Formation, the Hannoura Formation, the Suso Formation, the Izumo Member of the Horimatsu Formation and the Kurahara Formation.

Isurus oxyrhinchus Rafinesque, 1810
(Plate IV, Figure 8)

1810 *Isurus oxyrhinchus* Rafinesque, p. 12, pl. 13, fig. 1.
1954 *Isurus* cfr. *glaucus* (Muller and Henle) : Hoijier, p. 482, pl. 2, figs. 15, 16.
1956 *Isurus oxyrhinchus* Rafinesque : Gherardoni, p. 37, pl. 2, fig. 15.
1977 *Isurus oxyrhinchus* Rafinesque : Landini, p. 110, pl. 3, figs. 1-8.
non 1980 *Isurus oxyrhinchus* Rafinesque : Case, p. 82, pl. 2, figs. 4-8.
non 1980 *Isurus oxyrhinchus* Rafinesque : Uyeno *et al.* p. 127, pl. 2, figs. E, G-K.
non 1981 *Isurus oxyrhinchus* Rafinesque : Case, p. 57, pl. 2, figs. 3-5.
1985 *Isurus oxyrhinchus* Rafinesque : Kuga, p. 13, pl. 10, fig. 1.

Materials : One lateral tooth specimen (KUE0103) from Loc. 14.

Diagnosis : Teeth large and similar between jaws ; crowns slender for the species of the genus.

Descriptions : Tooth large and lacks root ; crown with sharp cutting edge, slender, acute triangular, thin and oblique to distal side ; mesial margin gently concave from base to central part and nearly straight from central part to apex, and distal margin nearly straight ; labial face nearly flat and lingual face moderately convex.

Remahks : Case (1980) reported *I. oxyrhinchus* from the Miocene Trent Formation in America but his specimens obviously belong to the teeth of *I. desori.* Case (1981) also described *I. oxyrhinchus* from the Eocene Formation in America. However, in main tooth characteristics, his specimens are quite identical with the specimens of *I. praecurusor. I. oxyrhinchus* may be a descendant of *I. desori* and fossil records of it can be go back to the Pliocene time (Landini, 1977 and Kuga, 1985).

Occurrence : The Pleistocene Zukawa Formation.

Order Galeiformis
Family Scyliorhinidae
Genus *Scyliorhinus* Blainville, 1816

Type species : *Squalus canicula* Linnaeus, 1788

Geologic range : Cretaceous-Recent.

Scyliorhinus kasenoi, nov. sp.
(Plate Ⅷ, Figures 1-4)

Materials : Three anterior teeth specimens (KUE0002, 1316-1317) and eight lateral teeth specimens (KUE0003-0005, 1318-1322) from Loc. 7 ; one lateral tooth specimen (KUE1720) from Loc. 8.

Holotype : One anterior tooth specimen (KUE0002) from the Suso Formation at Loc. 7.

Paratype : Two lateral teeth specimens (KUE0003 and KUE0004) from the Suso Formation at Loc. 7.

Type locality : Hannoura, Notojima-machi, Kashima-gun, Ishikawa Prefecture [37° 7′ N, 136° 56′ 50″E] .

Formation : The Middle Miocene Suso Formation.

Etymology : Named in honor of Professor Emeritus Yoshio Kaseno of Kanazawa University, an eminent geologist.

Diagnosis : Teeth very small (1.5-3.0mm) and similar between jaws ; crowns elongate, conical towards apex, depressed with development of weak cutting edges, and reflexed in lingual direction ; labial faces moderately convex and lingual faces strongly convex ; beses of crowns with many fine striae, broad, and possesses no or some pairs of very small lateral cusplets with striae.

Descriptions : Holotype (KUE0002) ; -nearly perfectly preserved anterior tooth with a length of 3.0mm ; crown with weak cutting edge, elongate, slender, conical towards apex and reflexed in lingual direction ; apex of cusp oblique to distal side ; mesial and distal margins slightly concave ; labial face with coarse striae moderately convex and lingual face with many fine striae, strongly convex ; base of crown broad and developed one small lateral cusplet at distal side ; lateral cusplet with weak cutting edge, conical toward apex of cusp ; both edges of base at labial side protruded to radical direction ; root wide and thick ; labial face nearly flat and lingual face of root with strong central ridge and deep central groove, and strongly convex ; apexes of root protruded to radical direction. Paratype (KUE0003) ; -nearly perfectly preserved lateral tooth with a length of 2.0mm ; crown with weak and smooth cutting edge, slender, elongate, and conical toward apex ; apex of cusp strongly oblique to distal direction and reflexed in lingual side ; mesial and distal margins slightly concave ; labial face with fine striae slightly convex and lingual face with fine striae strongly convex ; bases of crowns broad and possess single pair of very small lateral cusplets ; lateral cusplets with smooth margins and some fine striae, conical toward apex of cusp ; bases of distal and mesial edges at labial faces protruded to radical direction ; root wide and thick ; labial face of root nearly flat and lingual face of root with central groove strongly convex ; apexes of root protruded to radical direction. Lateral tooth of Paratype (KUE0004) lacks root, very small (tooth length of 1.5mm) ; crowns with weak cutting edge, slender, elongate, conical toward apex and slightly oblique to distal direction ; mesial and distal margins slightly concave ; labial face with fine striae moderately convex and lingual face with fine striae strongly convex ; base of crown board and bears one pair of small lateral cusplets ; lateral cusplets with weak cutting edge and some fine striae, conical toward apex of cusp. Referred specimens (KUE0005, 1316-1322, 1720) very small (tooth length of 1.5-3.0mm) but show diagnostic characters of the species.

Remarks : The present new species is the first record of the Scyliorhinid from the

Japanese Miocene formations.

The well-known Miocene species, *Scyliorhinus distans* has the crown with large lateral cusplets and rough striae. *S. kasenoi* is clearly distinguished from *S. distans* in having small crown with fine striae. *S. kasenoi* is similar to *S. joleaudi* Cappetta from the Miocene Formation in France (Cappetta, 1970) and *S. coupatezi* Herman *et al.* from the Early Pliocene Formation in Belgium (Herman *et al.*, 1975). However, the teeth of S. *joleaudi* and *S. coupatezi* are slender, reflex strongly in distal direction and possess small and slender lateral cusplets as compared with ones of *S. kasenoi.*

Occurrence : This species occurred in the Miocene Suso Formation and the Miocene Izumo Member of the Horimatsu Formation.

Family Hemigaleidae

Genus *Hemipristis* Agassiz, 1843

Type species : *Hemipristis serra* Agassiz, 1843

Geologic range : Eocene-Recent.

Hemipristis serra Agassiz, 1843

(Plate Ⅷ, Figure 5, 6)

1843 *Hemipristis serra* Agassiz, p. 237, pl. 27, figs. 18-30.

1970 *Hemipristis serra* Agassiz : Cappetta, p. 28, pl. 11, figs. 1-18.

1985 *Hemipristis serra* Agassiz : Itoigawa *et al.*, p. 29, pl. 6, figs. 1-15.

Materials : One upper tooth specimen (KUE0065) from Loc. 11 ; one upper tooth specimen (KUE0070) from Loc. 3.

Diagnosis : Teeth moderate in size and very different in upper and lower jaws ; crowns of upper teeth with serrated cutting edge, triangular ; crowns of lower teeth with cutting edge, slender and elongate.

Descriptions : Upper teeth remain crowns and moderate in size ; crowns with cutting edge, triangular, wide, thin and reflexed in labial direction ; apexes of crowns oblique to distal side ; mesial margins with fine serrations strongly convex and distal margins with very coarse serrations at base to central part, strongly concave ; labial faces slightly concave and lingual faces gently convex.

Remarks : *Hemipristis serra* has many fine serrations as compared with *H. cruvatus.* The upper tooth of *H. elongatus* has finer serrations than that of *H. serra.*

Occurrence : The Miocene Sekinobana Formation and the Miocene Kurahara Formation.

Family Carcharhinidae

Genus *Galeocerdo* Muller and Henle, 1837

Type species : *Squalus cuvier* Leusueur, 1822

Geologic range : Eocene-Recent.

Galeocerdo aduncus Agassiz, 1843
(Plate Ⅷ, Figures 8, 9)

1843 *Galeocerdo aduncus* Agassiz, p. 231, pl. 26, figs. 24-28.
1970 *Galeocerdo aduncus* Agassiz : Cappetta, p. 50, pl. 12, figs. 1-21.
1985 *Galeocerdo aduncus* Agassiz : Itoigawa *et al.*, p. 30, pl. 5, figs. 1-24.

Materials : Two teeth specimens (KUE0065, 0098) from Loc. 3.

Diagnosis : Teeth very similar between jaws ; crowns with main cusp and many lateral cusplets, moderate ; main cusp slender for the genus ; cutting edges possess fine serrations.

Descriptions : Tooth remains main cusp and one lateral cusplet (KUE0065) and tooth remains main cusp (KUE0098), moderate in size ; crowns with cutting edge, wide, thick and strongly oblique to distal direction ; cutting edges with many fine serrations ; mesial margins moderately convex and distal margins slightly concave ; labial faces nearly flat and lingual faces moderately convex.

Remarks : *G. latidens* (Agassiz) (including *G. alabamaensis* Leriche as the synonym) from the Eocene beds is distinguished from *G. aduncus* by having small teeth with coarse serrations and small subcusps. *G. cuvieri* (Leusueur) differs from *G. aduncus* by having large teeth with fine serrations and large main cusps.

Occurrence : The Miocene Sekinobana Formation.

Genus *Carcharhinus* Blainville, 1816

Type species : *Carcharhinus melanopterus* Quoy and Gaimard, 1824

Geologic range : Eocene-Recent.

Carcharhinus acanthodon (Le Hon, 1871)
(Plate Ⅷ, Figure 16)

1871 *Carcharias acanthodon* Le Hon, p. 9, pl. 1, figs. 17-23.
1969 *Carcharhinus* (*Hypoprion*) *lusitanicus* Jonet, p. 67, pl. I, figs. 1-8, 10-16 ; pl. IV, figs. 26, 27.
1969 *Carcharias* (*Hypoprion*) *acanthodon* (Le Hon) : Menesini, p. 28, pl. 7, figs. 17-19.
1970 *Hypoprion acanthodon* (Le Hon) : Antnes and Jonet, p. 168, pl. 15, figs. 100-108.
1974 *Negaprion* sp. Itoigawa and Nishimoto, p. 250, pl. 83, fig. 48.
1985 "*Negaprion*" cfr. *acanthodon* (Le Hon) : Itoigawa *et al.*, p. 34, pl. 7, figs. 1-22.

Materials : One upper tooth specimen (KUE0023) from Loc. 3.

Diagnosis : Teeth very different between upper and lower jaws, small to moderate ; crowns of upper teeth with cutting edge, slender, elongate and possess some very coarse serrations at base ; crowns of lower teeth with cutting edge, slender, erect and bear no serrations.

Descriptions : Imperfectly preserved upper tooth moderate ; crown with sharp cutting edge, slender, elongate, thin and oblique to distal direction ; base of crown with some very coarse serrations, board ; both margins nearly straight ; labial face nearly flat and lingual face moderately convex ; cervical band clear and thin ; root rectangular, wide and thin.

Remarks : Hasegawa and Uyeno (1967) and Itoigawa and Nishimoto (1974) included *C.*

acanthodon in the genus *Negaprion*. However, the living *Negaprion acutidens* has no serrations at the base of the crown and *N. breviostris* has very fine serrations at the base of the crown. These two species have comparatively wide cusps and large crowns. Therefore, *C. acanthodon* does not belong to the genus *Negaprion*. On the other side, the living species, *Carcharhinus hemiodon* and *C. macloti* which may be included in the genus *Hypoprion* have comparatively small teeth, narrow cusps, and very coarse serrations at bases of crowns of upper teeth. Those teeth characters are quite identical with those of *C. acanthodon*.

Occurrence : The Miocene Sekinobana Formation.

Carcharhinus egertoni (Agassiz, 1843)
(Plate I, Figures 9-12)

1843 *Corax egertoni* Agassiz, p. 228, pl. 36, figs. 6, 7.
1942 *Prionodon egertoni* (Agassiz) : Leriche, p. 80, pl. 7, figs. 1-11, 13-22.
1942 *Sphyrna* (*?*) *americana* Leriche, p. 86, pl. 6, figs. 6-8.
1970 *Carcharhinus egertoni* (Agassiz) : Antnes and Jonet, p. 189, pl. 15, figs. 110-111.
1974 *Carcharhinus egertoni* (Agassiz) : Menesini, p. 114, pl. 7, figs. 7-15.
1980 *Carcharhinus* aff. *egertoni* (Agassiz) : Nishimoto *et al.*, p. 214, pls. 12-13.
1983 *Carcharhinus* sp. Karasawa, p. 187, pl. 53, fig. 9.
1985 *Carcharhinus egertoni* (Agassiz) : Itoigawa *et al.*, p. 31, pl. 11, figs. 11-29.

Materials : Two upper teeth specimens (KUE0010, 1721) and one lower tooth specimen (KUE0013) from Loc. 3 ; eight upper teeth specimens (KUE1401-1408) and two lower teeth specimens from Loc. 4 ; one lower tooth specimen (KUE1583) from Loc. 5 ; twelve upper teeth specimens (KUE1001-1012) from Loc. 6 ; twenty-six upper teeth specimens (KUE0011, 0013, 1046-1069) and nine lower teeth specimens (KUE1070-1078) from Loc. 7.

Diagnosis : Teeth small and dissimilar between jaws ; crowns of upper teeth with sharp cutting edge, acute triangular ; crowns of lower teeth with sharp cutting edge at apex to central part, slender, and elongate ; cutting edges developed fine serrations.

Descriptions : Upper teeth moderate ; crowns of upper teeth with sharp cutting edge, acute triangular, wide, thin and oblique to distal side ; cutting edges with fine serrations from apex to base and with rough serrations at base ; mesial margins moderately convex and distal margins slightly concave ; labial faces nearly flat and lingual faces moderately convex. Lower teeth small to moderate ; crowns of lower teeth with sharp cutting edge, slender, elongate and slightly oblique to distal side ; crowns with fine serrations at apex to central part and round at central part to base ; both margins nearly straight ; labial faces nearly flat and lingual faces moderately convex. Roots of upper and lower teeth with weakly central ridges and central grooves on lingual faces, rectangular, wide and nearly flat. Apexes of roots moderately protruded to radical direction.

Remarks : This is well-known from the Miocene formations in the world and the occurrence of *C. egertoni* in Japan was reported by Nishimoto and Itoigawa (1977). *Sphyrna americana* is considered to be synonymous with *C. egertoni,* because *Sphyrna*

americana Leriche are merely large forms of *C. egertoni*.

Occurrence : It is known to occur in the Miocene sequences as the Sekinobana Formation, the Higashi-innai Formation, the Maenami Formation, the Hannoura Formation and the Suso Formation.

Carcharhinus priscus (Agassiz, 1843)

(Plate Ⅷ, Figures 13-15)

1843 *Sphyrna phisca* Agassiz, p. 234, pl. 24, figs. 35-49.

1927 *Sphyrna prisca* Agassiz : Leriche, p. 85, pl. 16, fig. 18.

1969 *Cestracion priscus* (Agassiz) : Menesini, p. 35, pl. 6, figs. 10-16.

1983 *Carcharhinus* sp. Karasawa, p. 187, pl. 53, fig. 11.

Materials : eighteen upper teeth specimens (KUE0007, 1501-1517) and six lower teeth specimens (KUE1518-1523) from Loc. 1 ; thirty-three upper teeth specimens (KUE0009, 1668-1673, 1803-1821) and eight lower teeth specimens (KUE0008, 1674, 1675, 1822-1826) from Loc. 3 ; fifty-four upper teeth specimens (KUE1411-1464) and sixteen lower teeth specimens (KUE1465-1480) from Loc. 4 ; ten upper teeth specimens (KUE1584-1593) and twelve lower teeth specimens (KUE1594-1607) from Loc. 5 ; twenty-nine upper teeth specimens (KUE1013-1041) and four lower teeth specimens (KUE1042-1045) from Loc. 6 ; ninety-three upper teeth specimens (KUE1079-1171) and twenty-nine lower teeth specimens (KUE1173-1200) from Loc. 7 ; ten upper teeth specimens (KUE1721-1730) from Loc. 8 ; ten upper teeth specimens (KUE2500-2509) from Loc. 10.

Diagnosis : Teeth small and dissimilar between jaws ; crowns of upper teeth with cutting edge, triangular ; crowns of lower teeth with cutting edge, slender ; cutting edges bear fine serrations.

Descriptions : Upper teeth moderate ; crowns of upper teeth with sharp cutting edge, acute triangular, wide, thin and oblique to distal side ; cutting edges with fine serrations ; mesial margins moderately convex and distal margins moderately concave ; labial faces nearly flat and lingual faces moderately convex. Lower teeth small to moderate ; crowns of lower teeth with sharp cutting edge, slender, elongate, thin and oblique to distal direction ; cutting edges with fine serrations ; both margins nearly straight ; labial faces nearly flat lingual faces moderately convex. Roots of upper and lower teeth, rectangular, wide and thin.

Remarks : The occurrence of this species in Japan were first recorded from the Miocene Mizunami Group by Itoigawa and Nishimoto (1974). The upper tooth of *Carcharhinus priscus* with equal and fine serrations is easily distinguished from ones of *C. egertoni* which the crown has equal and fine serrations near apex and unequal and rough serrations at base. The lower tooth of *C. priscus* with fine serrations differs from ones of *C. egertoni* with fine serrations at apex to central part.

Occurrence : The species occurs in the Miocene formation as the Wajimazaki Formation, the Sekinobana Formation, the Higashi-innai Formation, the Maenami Formation, the Hannoura Formation, the Suso Formation, the Izumo Member of the Horimatsu Formation, the Kurahara Formation and the Takakubo Formation.

Carcharhinidae gen. et sp. indet.
(Plate IX, Figures 1-3)

Materials : Three vertebrae (KUE0019-1921) from Loc. 12.

Descriptions : Cranial and caudal surfaces with scripted ring groups, nearly round and concave ; canals of haemal arches at dorsal surface and neural arches at ventral surface clear, and rectangular ; wall faces of canals of neural arches at ventral surface slightly convex and that of ventral surface nearly flat ; canals of neural arches wider than ones of haemal arches ; lateral faces nearly flat ; vertebrae plate 1.5 to 1.8mm in thickness.

Remarks : These vertebrae were collected from the same locality and are considered to come from the same individual.

These vertebrae belong to the vertebrae of the family Carcharhinidae because the cranial and caudal surfaces are round with ring groups, the canal of haemal arch at the dorsal surface and the canal of neural arch of the ventral surface form rectangular grooves, the lateral surfaces are nearly flat, and the notchoral foramen does not open. The features of these specimens are also similar to ones of *Carcharhinus egertoni* from the Higashibessho Formation (Nishimoto *et al.*, 1980 as *C.* aff. *egertoni*).

Reference

Agassiz, L. (1843), Recherches sur les poissons fossiles. vol. 3, p. 1-390, 83pls., Neuchatel.

Applegate, S. and T. Uyeno (1968), The First Discovery of a fossil belonging to the Shark Genus *Heptranchias,* with a Spine, Both from the Oligocene of Japan. *Bull. Nat. Sci. Mus.* vol. 11, no. 2, p. 195-200, pl. 1.

Antnes, M. T. and S. Jonet (1970), Requins de l' Helvêtien supérieuor et du Tortonien de Lisbone. *Rev. Fac. Ciênias de Lisboa.* ser. C, no. 16, p. 119-280, 20pls.

Bito, A., T, Hayasaka, Y. Kaseno, K. Ogasawara and T. Takayama (1980), The Neogene stratigraphy around Kaga City, Ishikawa Prefecture, Japan. *Ann. Sci. Kanazawa Univ.,* no. 17, p. 45-77. (in Japanese with English abstract)

Bosch, M. van den (1971), Elasmobranch uit het Rupelien van Lintorf hij Dusseldorf (Westdutsland). *Meded. Werkgr. Tert. Kwant. Geol.,* vol. 8, no. 2, p. 46-61.

.....(1984), Oligocene to Recent Cetorhinidae (Vertebrata, Basking sharks) ; problematical find of teeth, dermal scales and gill-rakers. *ibid.,* vol. 21, no. 4, p. 205-232, pls. 1-3.

Cappetta, H. (1970), Les sélaciens du Miocène de la région de Montpellier. *Palaeovertebrata, Mem. Extr.* 1970, p. 1-130, 27pls.

.....(1987), Chondrichthyes II, Mesozoic and Cenozoic Elasmobranchii. 193p., Handbook of Paleoichthyology, vol. 3B, Gustav Fischer Verlag. Stuttgrt. New York.

Case, G. R. (1980), A selachian fauna from the Trent formation, Lower Miocene (Aquitanian) of eastern North Carolina. *Palaeontgraphica.* Abt. A, no. 171, p. 75-103, pls. 1-10.

.....(1981), Late Eocene selachians from south-central Georgia. *ibid.,* no. 176, p. 52-79, pls. 1-9.

Casier, E. (1958), Contribution a l'etude des poissons fossiles des Antilles. *Mem. Suisses Paleontol.,* vol. 74, p. 1-95, 3pls.

.....(1960), Notes sur la collection des poissons paleocenes et eocenes de l'Enclave de Cabinda (Congo). *Ann. Mus. Roy. Congo Belge,* ser. 3, vol. 1, no. 2, p. 1-48, pls. 1, 2.

Compagno, L. J. V. (1973), Interrelationships of living elasmobranchs. in Greenwood et al. (ed.), Interrelationships of fishes, p. 15-61, Academic Press, London.

……(1984), An annoteded and illustrated catalogue of sharks species known to date, Part 1 -Hexanchiformes to Lamniformes, Part 2-Carcharniformes. *FAO Fisheris Synopsis,* No. 125, vol. 4, part 1, 249p. part 2, p. 251-655.

Fuji, N. (1982), Geography, Geology and Climate. *History of the Noto-jima,* vol. 1. (in Japanese)

Ghelardoni, R. (1956), Resti Fossili di Pesci nel Livella (Purpula) delle sabbie di torre del Lago (Viareggio). *Att. Soc. Tosc. Soc. Nat.,* Ser. A, no. 63, p. 33-39, 2pls.

Goto, M. (1972), Fossil chondorichyes of Japan. *Jour. Geol. Soc. Japan,* vol. 78, no. 11, p. 585-600. (in Japanese with English abstract)

……. and H. Akabane (1982), A Fossil Shark Tooth of *Carcharodon megalodon* from the Yatsuo Group (middle Miocene) of Uozu City, Toyama Prefecture. *Bull. Toyama Sci. Mus.,* no. 4, p. 1-4, pl. 1. (in Japanese with English abstract)

……, and M. Goto (1987), Three Fossil Teeth of the Lomnoid Shark, *Carcharocles* and *Carcharodon* from the Hokuriku Group (late Miocene-early Pleistocene) of Takaoka City, Toyama Prefecture, Central Japan. ibid., no. 11, p. 123-132, pl. 1. (in Japanese with English abstract)

……, F. Kobayashi and S. Osawa (1982), On a dentition of grait exinct shark, *Carcharodon megalodon,* from Annaka City, Gumma Prefecture, Japan (Preliminary report). *Jour. Geol. Soc. Jap.,* vol. 89, no. 10, p. 597-598, 1pl. (in Japanese)

Hasegawa, Y. and T. Uyeno (1967), Fossil fishes. in Anancho no Kaseki ed. Tanaka, K., p. 113-117. (in Japanese)

Herman, J., M. Crochard and M. Giraridot (1974), Quelques restes de sélaciens récoltés dans les sabbes du Kattendiek a kallo. 1. Selachii-Euselachii. *Bull. Soc. belge Geologie,* vol. 83, no. 1, p. 15-31, 2pls.

Hoijer, D. A. (1954), Pleistocene Vertebrates from Celves. IX. Elasmobranch. *Proc. K. Wed. Akad. Wet. Leiden* (B), no. 57, p. 475-485, 2pls.

Hatai, K., K. Masuda and H. Noda (1974), Shark teeth from the Moniwa Formation. *Saito Ho-on Kai Mus. Res. Bull.,* no. 43, p. 9-26, pl. 1.

Ijima, S. (1985MS), Neogene Megafossils of the southern Toyama sedimentary basin. Kanazawa Univ. (In Japanese)

Ikeda, T. (1982), Miocene planktonic Foraminiferal biostratigraphy in the north-eastern part of the Noto Peninsula, Central Japan. *Earth Science,* vol. 36, no. 1, p. 1-9. (in Japanese with English abstract)

Inuzuka, N. and H. Karasawa (1986), Some fossils of *Paleoparadoxia* from Miocene Calcareous Sandstones on the Noto Peninsula, Central Japan. *Earth Science,* vol. 40, no. 4, p. 293-300. (in Japanese)

Ishiwara, Y. (1921), On some fossil Shark teeth from the Neogene of Japan. *Sci. Rep. Tohoku Imp. Univ.,* ser. 2, no. 5, p. 61-74.

Itoigawa, J. and H. Nishimoto (1974), Elasmobranch fossils from the Miocene Mizunami Group. *Bull, Mizunami Fossil Mus.,* no. 1, p. 243-262, pls. 79-85. (in Japasese)

……., ……., H. Karasawa and Y. Okumura (1985), Miocene fossils of the Mizunami group, central Japan, 3. Elasmobranchs. *Monograph of the Mizunami Fossil Mus.,* no. 5, 89p., 38pls. (in Japanese)

……, ……, M. Kuroda, H. Horie, A. Naruse and Y. Watanabe (1975), *Carcharodon carcharias* (Linnaeus)-shark teeth-from the Pliocene Na-arai formation, Choshi Peninsula, environs of Toyo, Japan. *Bull. Mizunami Fossil Mus.,* no. 2, p. 91-102, pls. 19-22. (in Japanese with English abstract)

Japanese Group for Elasmobranch Studies (1984), Report of a preliminary investigation on sharks and rays in the Western Pacific Ocean. Japan. *Group Elasmobr. Stud. Spec. Publ.,* no. 1, p. 39-49.

Jonet, S. (1968), Notes d'Ichthyologie Miocene : II-Les Carcharinidae. *Bol. Mus. Lab. Min. Geol. Fac. Cien., Lisboa,* vol. 10, no. 2, p. 65-88, pls. 1-4.

Jordan, D. S. (1907), The fossil fishes of California with supplementary notes on other species of extinct fishes. *Bull. Dept. Geol., Univ. Calif. Publ.,* vol. 5, no. 7, p. 95-145.

Kamei, T. (1969), Shark vertebrae fossils from the upper Miocene formation of Noto Peninsula. *Bull. Fossil Club,* no. 2, p. 20-23, 1pl. (in Japanese)

Kami, S., M. Kato, K. Kuchida and T. Takayama (1981), Geological Ages of Calcareous Sandstones on the Noto Peninsula. *Ann. Sci. Kanazawa Univ.,* no. 18, p. 47-63. (in Japanese with English abstract)

Karasawa, H. (1983), Fossil Elasmobranch Teeth from the Miocene Formations in Noto Peninsula, Central Japan. *Bull. Mizunami Fossil Mus.,* no. 10, p. 185-192, pls. 51-53. (in Japanese)

……(1987MS), The stratigraphical and paleontlogical studies of the middle Miocene deposits of northern Noto Peninsula. Kanazawa Univ. (in Japanese with English abstract).

Kaseno, Y. (1977), Environmental Geology of Ishikawa Prefecture. Natual Environment of Ishikawa Prefecture. vol. 1, Geography and Geology, p. 1-128. (in Japanese)

……(1984), Occurrence and Stratigraphical Horizon of the Desmostylian Fossils from Noto, Japan. *Desmostylus* and environment, *Monograph of the Assotiation for the Geological Coraborarion in Japan,* no. 28, p. 63-72. (in Japanese with English abstract)

……, S. Ijima, M. Nakayama and A. Kato (1985), The sedimental and tectonical history during late Cenozoic in the northweatern Toyama sedimentary basin. *Abstracts of the 92th Annual Meeting of the Geological Society of Japan,* p. 113.

Katto, J., Y. Sako and K. Hatai (1977), Additional fossils from Southweat Japan. *Res. Rep. Kochi Univ.,* vol. 25, no. 12, p. 101-105, pl. 1.

Kemp, N. R. (1978), Detailed comparisons of the dentitions of extinct Hexanchid sharks and Tertiary Hexanchid teeth from South Australia and Victoria, Austtaria (Selachii : Hexanchidae). *Mem. Nat. Mus. Victoria.* vol. 39, p. 61-83, 4pls.

Keyes, I. W. (1971), New records of the Elasmobranch *C. megalodon* (Agassiz) and a review of the genus *Carcharodon* in the New Zealand fossil record. *N. Z. Jour. Geol. and Geophys.,* vol. 15, no. 2, p. 228-242.

……(1982), The Cenozoic sawshark *Pristiophorus lanceolatus* (Davis), (Order Selachii) of New Zealand and Australia, with a review of the phylogeny and distribution of world fossil and extant Pristiophoridae. *ibid,* vol. 25, p. 459-474.

……(1984), New records of fossil elasmobranch genera *Megascyliorhinus, Centrophorus* and *Dalatias* (Order : Selachii) in New Zealand. *ibid.,* vol. 27, p. 203-216.

Kuga, N. (1985), Revision of Neogene Mackerel Shark of Genus *Isurus* from Japan. *Mem. Fac. Sci. Kyoto Univ., Geol. and Mineral,* vol. 51, p. 1-18, pls. 1-10.

……and M. Goto. (1982), Tooth Morphology and Terminology of Elasmobranchs. *Aquabiol,* vol. 2, no. 5, p. 383-387. (in Japanese with English abstract)

……and M. Nomura (1987), Elasmobranchs from the Nanao calcareous Sandstone (middle Miocene) in Nanao City, Ishikawa Prefecture. *Abstracts of the 136th Regular Meeting of the Palaeontological Society of Japan,* p. 8.

Landini, R. (1977), Revisione degli (Ichiodontoliti pliocenisi) della callezione marines lawleys. *Palaeont. Italica,* vol. 70, p. 92-134, pls. 1-5.

Leriche, M. (1927), Les poissons de la Mollasse suisse. *Mem. Soc. paléont. Suisse,* vol. 47, no. 2, p. 27-117, pls. 8-14.

……(1942), Contribution à l'étude des faune ichthyologuques marines des terrains teriarires de la plaine côteére atlantique et du centre des Etats-Unis. *Mém. Soc. géol. France,* vol. 20, 110p. 8pls.

……(1957), Les poissons neogenes de la Bretagne, de l'Anjou et de la Touraine. *ibid.,* vol. 36, 64p. 4pls.

……and E. Casier (1954), Les faunes ichthyologiques marines du Neogene des Indes orientals. *Schweiz. Paleont. Ah.,* vol. 70, p. 1-21, 2pls.

Matsuura, N., A. Fujii, N. Sekido and A. Kawai (1984), Fossil materials of Kaga. V. Echinodelmata, Brachiopoda, Cirripedia and Elasmobranch fossils from the Neogene and Quarternary formations. *Nature of Ishikawa,* no. 8, p. 21-25, pls. V-2. (in Japanese)

……and O, Horita (1986), Fossil materials of Noto (Secondary Volume), *ibid,* vol. 10, p. 21-25, pl. III-3. (in Japanese)

Menesini, E. (1969), Ittiodontoliti mioceni di Terra d'Otranto (Paglia), *Palaeont. italica,* vol. 65, 65p. 7pls.

……(1974), Ittiodontoliti delle formazione terzione dell'Aecipelaga Maltese., *Palaeontgraphica,* vol. 37, 74p., 8pls.

Nakagawa, T. and Y. Yasuno (1985), On the fossil gill raker of the basking shark from the Miocene formation in the Northern part of Fukui Prefecture, central Japan. *Jour. Geol. Soc. Japan,* vol. 39, no. 3, p. 231-232, pl. 1. (in Japanese)

Nishimoto, H. and J. Itoigawa (1977), Elasmobranchia assemblages of Cenozoic formations in south west Japan. *Bull. Mizunami Fossil Mus.,* no. 4, p. 194-196. (in Japanese)

……, M. Tatemastu and H. Sawada (1980), Fossil Skull of Elasmobranch from the Miocene Hokuriku Group, Central Japan. *ibid.,* no. 7, p. 113-115, 2pls. (in Japanese)

……, and A. Ujihara (1979), Fossil Elasmobranchs from the Miocene Morozaki Group, Central Japan. *ibid.,* no. 6, p. 53-64, pl. 9. (in Japanese with English abstract)

Schultz, O. (1971), Die Selachier-Fauna (Pisces, Elasmobranchii) des Wiener Beckens und seiner Randgebite im Badenuen (Miocene). *Ann. Mus. Wien,* no. 57, p. 311-341, pls. 1-4.

Takai, F. (1944), *Desmostylus* from the phosphorus beds of the Noto Peninsula. *Misc. Rep. Res. Inst. Nat. Res.,* no. 5, p. 59-62. (in Japanese)

Takayama, T. (1986), Nannofossils. *Paleontological Research Reports of The Nanao calcareous Sandstone in the Noto Peninsula.* p. 118-137. (in Japanese)

Ujihara, A., and H. Shibata (1982), Molluscs and Elasmobranchs from the Miocene Kumano Group in the Southern Part of Kii Peninsula, Japan. *Bull. Mizunami Fossil Mus.,* no. 11, p. 25-34. (in Japanese with English abstract)

Uyeno, T., Y. Hasegawa and T. Kakuta (1980), Some shark teeth from Miocene Ichishi Group in Mie Prefecture, Japan. *Bull. Nat. Sci. Mus.,* ser. c, vol. 6, no. 4, p. 125-128, pls. 1, 2.

……, N. Kashima and Y. Hasegawa (1975), Fossil shark teeth from Cretaceous and Tertiary Beds in Shikoku Island, Japan. *Mem. Nat. Sci. Mus.,* no. 8, p. 51-56, pl. 5. (in Japanese with English abstract)

……, K. Ono and O. Sakamoto (1983), Miocene Elasmobranchs from Chichibu Basin, Saitama, Japan. *Bull. Saitama Mus. Nat. Hist.,* no. 1, p. 27-36. (in Japanese with English abstract)

……and I. Oshiro (1982), Tertiary shark Teeth of *Carcharodon megalodon* and *Isurus benedeni* from Shimajiri Formation in Okinawa-jima. *Ann. Okinawa Prefectual Mus.,* no. 8, p. 1-7, pl. 1. (in Japanese)

……and O. Sakamoto (1984), Lamnoid shark *Carcharodon* from Miocene beds of Chichibu basin, Saitama Prefecture, Japan. *Bull. Saitama Mus. Nat. Hist.,* no. 2, p. 47-65, pls. 1-8. (in Japanese with English abstract)

……and H. Uematsu (1984), Middle Miocene Elasmobranchs from Sunagawa, Yamagata Prefecture.

Mem. Nat. Sci. Mus. Tokyo, no. 17, p. 35-38, pls. 3-5. (in Japanese with English abstract)

....., Y. Yabumoto and N. Kuga (1984), Fossil Fishes of Ashiya Group. *Bull. Kitakyushu Mus. Nat. Hist.,* no. 5, p. 135-142. (in Japanese with English abstract)

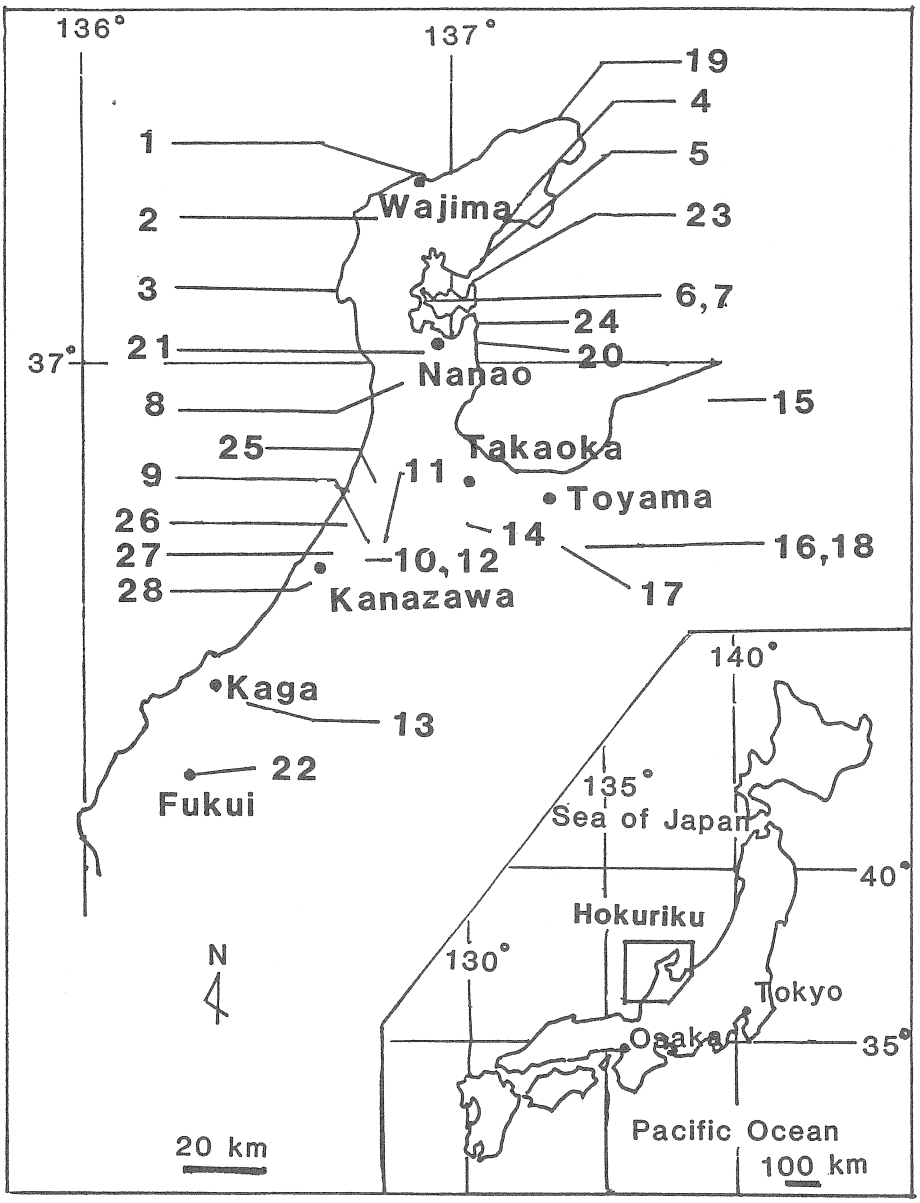


Figure 1. Map showing the fossil localities of elasmobranchs in the Hokuriku district

Table 1. Faunal Hst of clasmobranchs from the Late Cenozolc formatlons in the Hokurlku district.

Species \ Formation	Age	Miocene															Plio-Pleistocene			
	Area	Toyama			Noto										Kaga			Toyama	Noto		Kaga
		Kurosedani F.	Higashibessho F.	Otogawa F.	Higashi-innai F.	Najimi F.	Sekinobana F.	Wajimazaki F.	Andaibara F.	Maenami F.	Akaura F.	Hannoura F.	Suso F.	Iori F.	Horimatsu F.	Kurahara F.	Takakubo F.	Kinjosan F.	Hosokubo F.	Zukawa F.	Nozaki F.	Sakiyama F.	Suginoya F.	Omma F.
Hexanchus gigas (Sismonda)		+					+					+	+											
Dalatias licha (Bonnaterre)							+	+			+			+										
Squalus cfr. *serriculus* (Jordan and Hannibal)					+			+			+		+											
Pristiophorus sp.							+																	
Rajidae, gen. et sp. indet.								+																
Dasyatis sp.		+		+																				
Aetobatis sp.		+																						
Rhinoptera sp.		+					+				+													
Squatina sp.							+				+	+	+											
Eugomphodus acutissima (Agassiz)		+			+		+	+		+	+			+		+								
E. cuspidatus (Agassiz)							+	+		+	+	+	+	+	+									
Odontaspis volax (Le Hon)							+				+													
Alopias superciliosus (Lowe)		+					+																	
Cetorhinus maximus (Gunner)										+														
C. sp.																			+					
Paratodus benedeni (Le Hon)								+			+	+	+											
Carcharocles megalodon (Agassiz)		+				+	+	+		+	+	+	+	+	+	+	+				+			
Carcharodon carcharias (Linnaeus)																				+	+	+	+	+
Isurus desori (Agassiz)			+				+	+		+	+	+	+	+		+								
I. hastalis (Agassiz)		+				+	+	+	+	+	+	+	+	+	+	+	+							
I. planus (Agassiz)							+	+	+	+	+	+	+	+	+									
I. oxrhinchus (Rafinesque)																				+				
Scyliorhinus kasenoi nov., sp.													+		+									
Hemipristis serra Agassiz)							+																	
Galeocerdo aduncus Agassiz		+					+				+													
G. cuvieri (lesuer)																								+
Carcharhinus acanthodon (Le Hon)							+				+													
C. egertoni (Agassiz)		+	+		+		+	+		+	+	+	+	+	+									
C. priscus (Agassiz)		+		+	+		+	+		+	+	+	+	+	+	+	+	+						
C. spp.																				+				+
Carcharhinidae, gen. et sp. indet.																		+						

Table 2. Stratigraphic correlation of the elasmobranch-bearing formations in the Hokuriku district

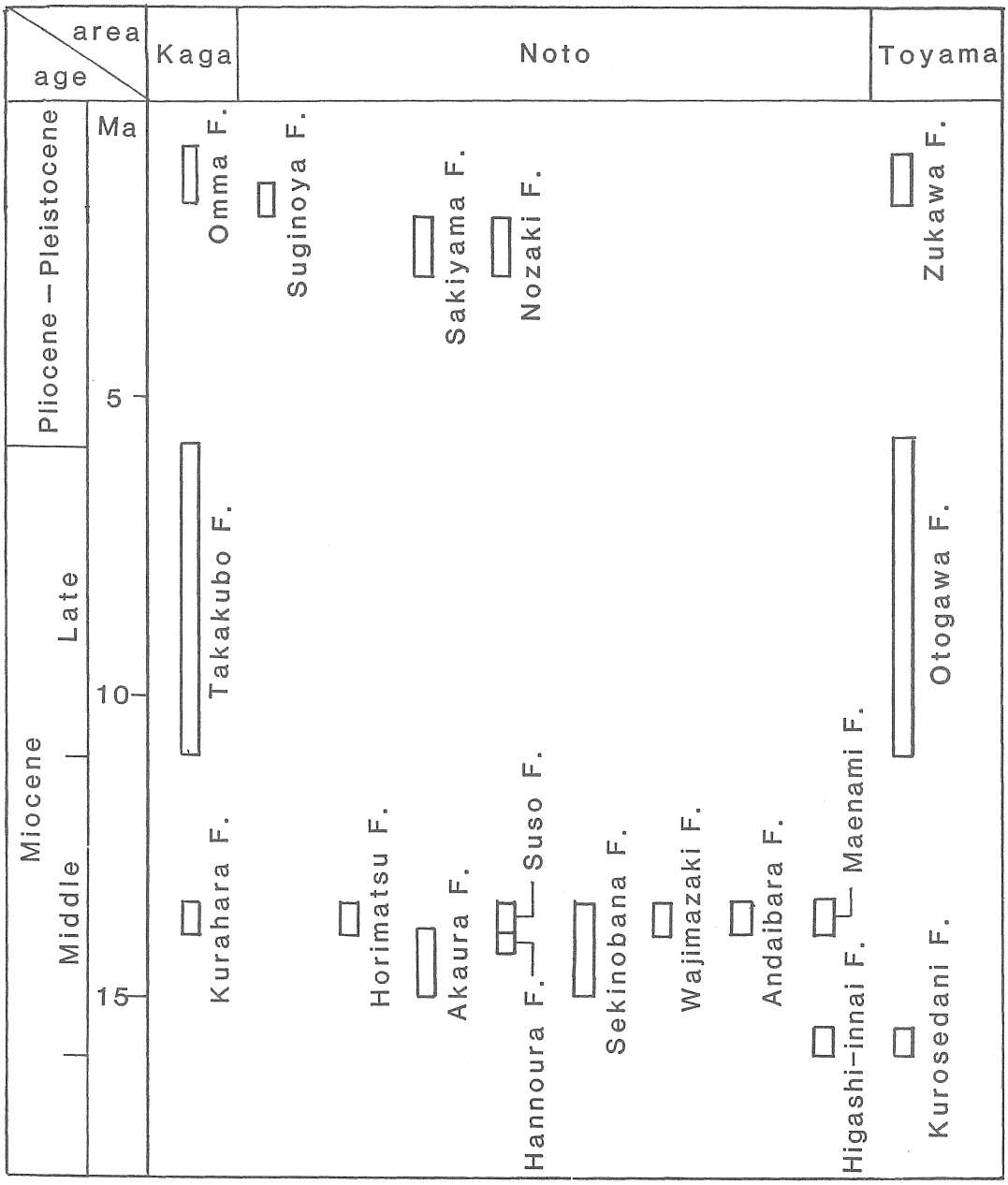


Table 3. List of elasmobranch assemblages from the Hokuriku district

Age		Formation	Assemblage	Dominant species	Subdominant species
Early Pleistocene		Omma F., Suginoya F., Zukawa F.	*Carcharodon - Carcharhinus*	*Carcharodon carcharias* *Carcharhinus* spp.	
Late Pliocene		Nozaki F., Sakiyama F.	*Carcharodon*	*Carcharodon carcharias*	
Miocene	Late	Takakubo F., Otogawa F.	*Carcharhinus*	*Carcharhinus priscus*	
	Middle	Hannoura F., Suso F., Horimatsu F.	*Carcharhinus - Eugomphodus* *Isurus*	*Carcharhinus priscus* *Eugomphodus cuspidatus* *Isurus hastalis* *Isurus planus*	*Scyliorhinus kasenoi* *Isurus desori*
		Middle and upper Sekinobana F., Kurahara F., Maenami F., Wajimazaki F.	*Carcharhinus - Isurus*	*Carcharhinus priscus* *Isurus hastalis* *Isurus planus*	*Eugomphodus acutissma* *Eugomphodus cuspidatus* *Isurus desori*
	14 Ma	Lower Sekinobana F., Nanao F.	*Isurus - Carcharhinus - Eugomphodus*	*Carcharhinus priscus* *Eugomphodus acutissima* *Eugomphodus cuspidatus* *Isurus hastalis* *Isurus planus*	*Isurus desori* *Odontaspis volax* *Carcharhinus egertoni*
	15 Ma	Higashi-innai F., Kurosedani F.	*Carcharhinus - (Eugomphodus)*	*Carcharhinus priscus*	*Eugomphodus acutissima*

Table 4. Associations of elastmobranch assemblages from the Late Cenozoic formations in the Hokuriku district.

Species \ Assemblage	1	2	3	4	5	6	7
Hexanchus gigas	VR	R		R			
Dalatias licha		R	R				
Squalus cfr. *serriculus*	R	R	R	R			
Pristiophorus sp.		R					
Dasyatis sp.	R				R		
Aetobatis sp.	VR						
Rhinoptera sp.	R	VR					
Squatina sp.			VR	R			
Eugomphodus acutissima	F	C	F				
E. cuspidatus		C	F	C			
Odontaspis volax		F					
Alopias superciliosus	VR	VR					
Cetorhinus maximus			VR				
C. sp.			VR				
Paratodus benedeni		VR	R	R			
Carcharocles megalodon	R	R	R	R	R	VR	
Carcharodon carcharias						C	C
Isurus desori		F	F	F			
I. hastalis	R	C	C	C	R		
I. planus		C	C	C			
I. oxyrhinchus							R
Scyliorhinus kasenoi				VR			
Hemipristis serra		VR	VR				
Galeocerdo aduncus	R	R					
G. cuvieri							R
Carcharhinus acanthodon		VR					
C. egertoni	R	F	R	F			
C. priscus	C	C	C	C	F		
C. spp.							C

C; Common, F; Frequent, R; Rare, VR; Very rare.

1; *Carcharhinus-(Eugamphodus)* ass., 2; *Isurus-Carcharhinus-Eugamphodus* ass., 3; *Isurus-Carcharhinus* ass., 4; *Carcharhinus-Eugomphodus-Isurus* ass., 5; *Carcharhinus* ass., 6; *Carcharodon* ass., 7; *Carcharodon -Carcharhinus* ass.

Table 5. The climatic and bathymetric distribution, and the modes of life of the recent elasmobranchs.

Genus	Climate			Bathymetry			Mode of life		
	Tropical	Subtropical	Temperate	Neritic	Epipelagic	Mesopelagic	Benthos	Nekton	Plankton
Hexanchus	+	+		+	+	+		+	
Dalatias	+	+		+	+	+		+	
Squalus	+	+	+	+	+			+	
Pristiophorus	+	+	+	+		+		+	
Dasyatis	+	+	+	+			+		
Aetobatis	+			+			+		
Rhinoptera	+			+			+		
Squatina	+	+	+	+		+	+		
Eugomphodus	+	+		+				+	
Odontaspis	+	+		+				+	
Alopias	+	+			+			+	
Cetorhinus	+	+	+	+	+			+	+
Isurus	+	+	+		+			+	
Carcharodon	+	+	+	+	+			+	
Scyliorhinus	+	+	+	+				+	
Hemipristis	+			+				+	
Galeocerdo	+	+		+				+	
Carcharhinus	+	+		+	+			+	

Table 6. Late Cenozoic Elasmobranch Assemblages and Inferred Paleoenvironments of the Hokuriku District

Age		Formation	Assemblage	Environment
Early Pleistocene		Omma F., Suginoya F. Zukawa F.	*Carcharodon-Carcharhinus*	neritic to epipelagic environment
Late Pliocene		Nozaki F., Sakiyama F.	*Carcharodon*	
Miocene	Late	Takakubo F., Otogawa F.	*Carcharhinus*	shallow sea with high temperature
	Middle	Hannoura F., Suso F., Horimatsu F.	*Carcharhinus-Eugomphodus* *-Isurus*	neritic to epipelagic environment under warm sea-water temperature
		Middle and upper Sekinobana F. Kurahara F., Maenami F., Wajimazaki F.	*Carcharhinus-Isurus*	
	14 Ma	Lower Sekinobana F., Akaura F.	*Isurus-Carcharhinus* *-Eugomphodus*	subtropical to temperate shallow environment influenced by epipelagic waters having high sea-water temperature in the upper layer
	15 Ma	Higashi-innai F., Kurosedani F.	*Carcharhinus-(Eugomphodus)*	tropical to subtropical shallow sea

Explanation of Plate I

All figures x 1.5 otherwise stated.

Figure 1. *Hexanchus gigas* (Sismonda, 1861).
KUE0001 : Lower lateral tooth. Loc. 6.

Figure 2. *Dalatias licha* (Bonnaterre, 1788).
KUE0057 : Lower tooth. Loc. 3.

Figures 3, 4. *Squalus* sp.
Figure 3. KUE0058 : Upper tooth. Loc. 4.
Figure 4. KUE0059 : Lower tooth, Loc. 7.

Figure 5. *Pristiophorus* sp. KUE0061 : Rostoral tooth. Loc. 3.

Figure 6. Rajidae, gen. et sp. indet. x 15.
KUE0063 : Tooth. Loc. 1.

Figure 7. *Rhinoptera* sp. KUE0080 : Tooth. Loc. 3.

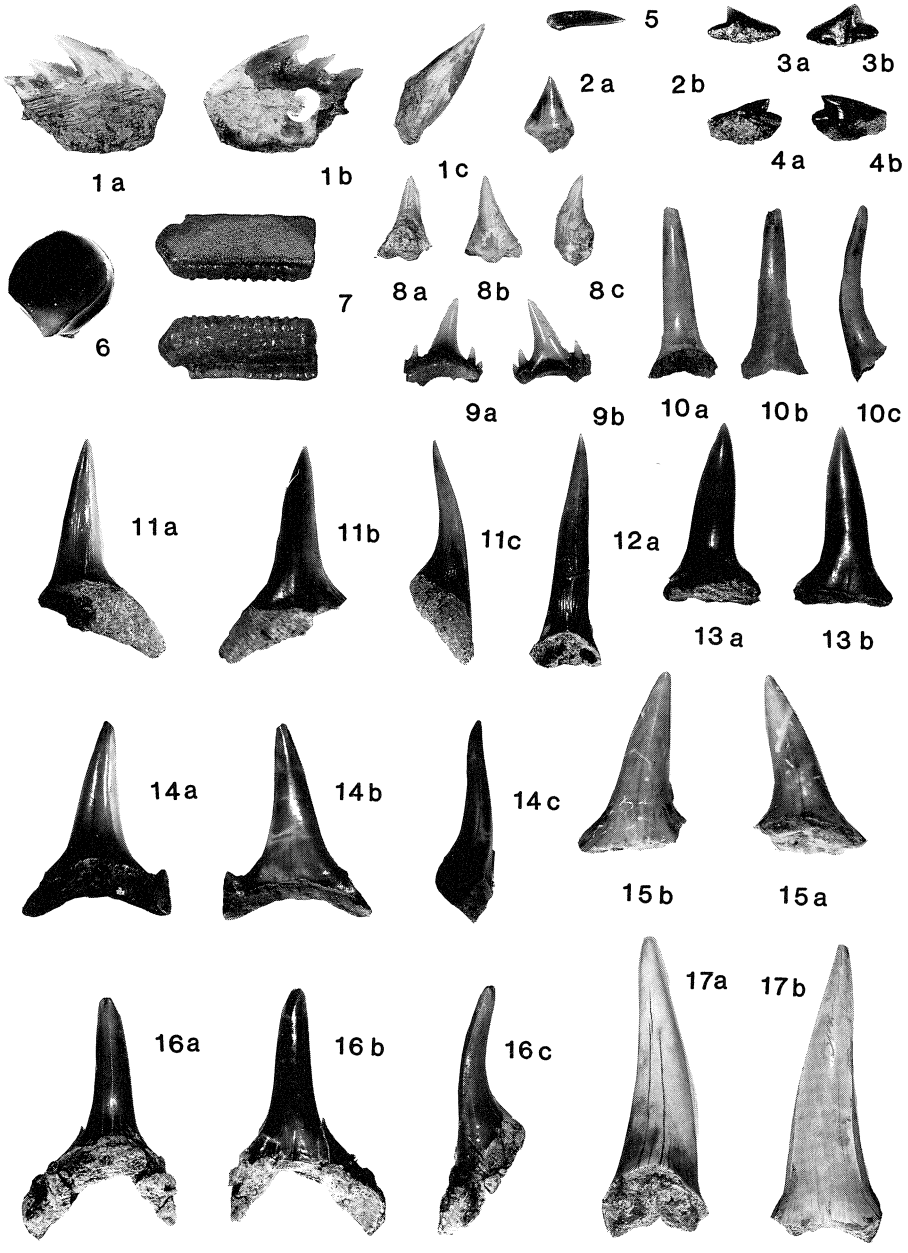
Figure 8. *Squatina* sp. KUE0062 : Tooth. Loc. 6.

Figures 9, 10. *Odontaspis volax* (Le Hon, 1871).
Figure 9. KUE0091 : Anterior tooth. Loc. 3.
Figure 10. KUE0092 : Lateral tooth. Loc. 3.

Figures 11, 12. *Eugomphodus acutissima* (Agassiz, 1843).
Figure 11. KUE0024 : Anterior tooth, Loc. 1.
Figure 12. KUE0025 : Anterior tooth, Loc. 1.

Figures 13-17. *Eugomphodus cuspidatus* (Agassiz, 1843).
Figure 13. KUE0026 : Anterior tooth, Loc. 7.
Figure 14. KUE0027 : Anterior tooth, Loc. 7.
Figure 15. KUE0028 : Lateral tooth, Loc. 7.
Figure 16. KUE0029 : Lateral tooth, Loc. 5.
Figure 17. KUE0030 : Anterior tooth, Loc. 6.
(a : Lingual view, b : Labial view, c : Lateral view)

Plate I


1a
1b
1c
2a
2b
3a
3b
4a
4b
5
6
7
8a
8b
8c
9a
9b
10a
10b
10c
11a
11b
11c
12a
13a
13b
14a
14b
14c
15b
15a
16a
16b
16c
17a
17b

Explanation of Plate II

All figures x 1.5 otherwise stated.

Figure 1. *Cetorhinus maximus* (Gunner, 1765)

KUE0033 : Tooth, Loc. 5.

Figure 2. *Alopias superciliosus* (Lowe, 1833).

KUE0032 : Lateral tooth, Loc. 3.

Figures 3-5. *Parotodus benedeni* (Le Hon, 1871).

Figure 3. KUE0036 : Lateral tooth, Loc. 1. x 1.0.

Figure 4. KUE0037 : Anterior tooth, Loc. 1.

Figure 5. KUE0038 : Lateral tooth, Loc. 7.

Figures 6-9. *Isurus desori* (Agassiz, 1843).

Figure 6. KUE0039 : Lower anterior tooth, Loc. 1.

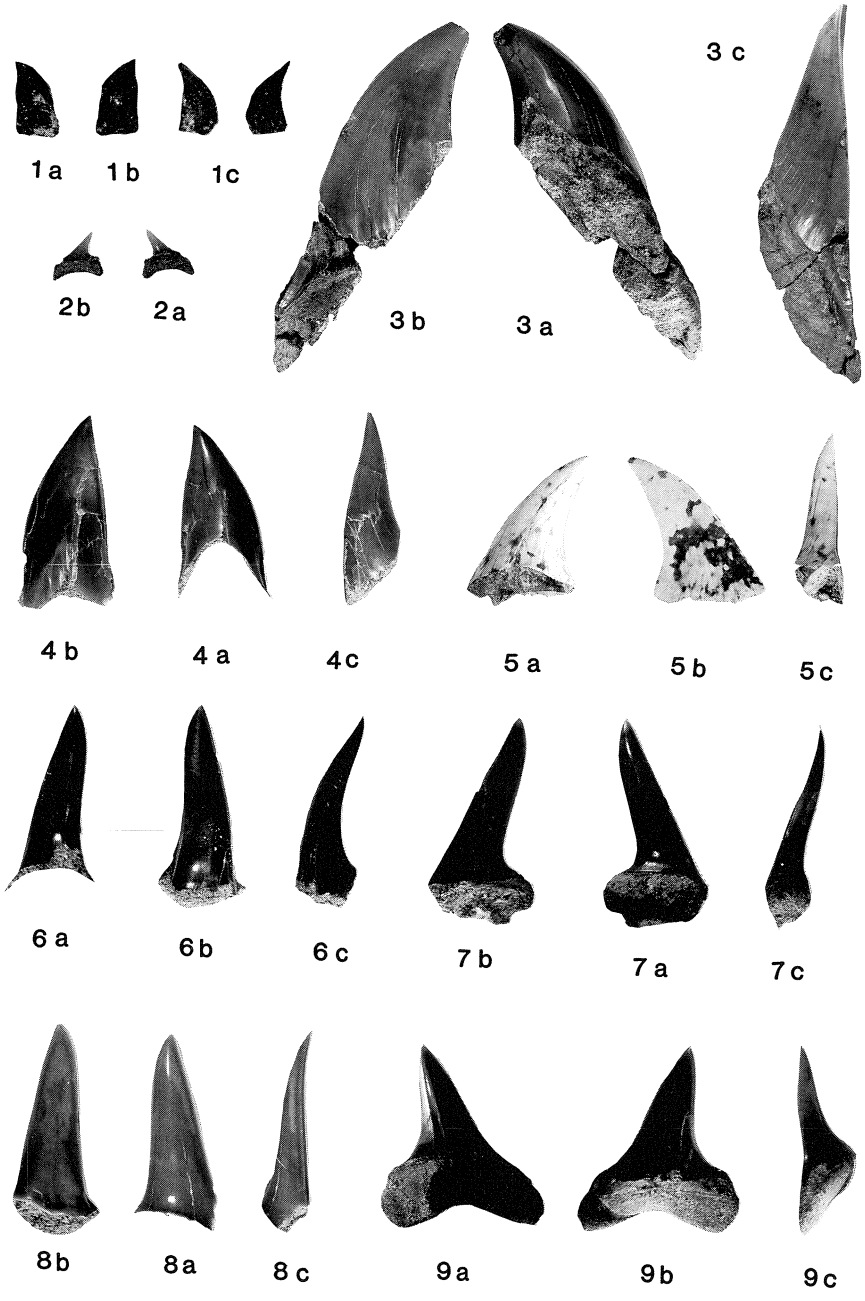
Figure 7. KUE0040 : Upper first anterior tooth, Loc. 1.

Figure 8. KUE0041 : Upper second anterior tooth, Loc. 3.

Figure 9. KUE0042 : Lateral tooth, Loc. 1.

(a : Lingual view, b : Labial view, c : Lateral view)

Plate II


1a
1b
1c
2b
2a
3b
3a
3c
4b
4a
4c
5a
5b
5c
6a
6b
6c
7b
7a
7c
8b
8a
8c
9a
9b
9c

Explanation of Plate III

All figures in natual size otherwise stated.

Figures 1-7. *Isurus hastalis* (Agassiz, 1843).

Figure 1. KUE0044 : Anterior tooth, Loc. 3. x 1.5.

Figure 2. KUE0043 : Lateral tooth, Loc. 9.

Figure 3. KUE0098 : Lateral tooth, Loc. 2.

Figure 4. KUE0047 : Lateral tooth, Loc. 9.

Figure 5. KUE0048 : Lateral tooth, Loc. 3. x 1.5.

Figure 6. KUE0046 : Lateral tooth, Loc. 6.

Figure 7. KUE0045 : Anterior tooth, Loc. 1.

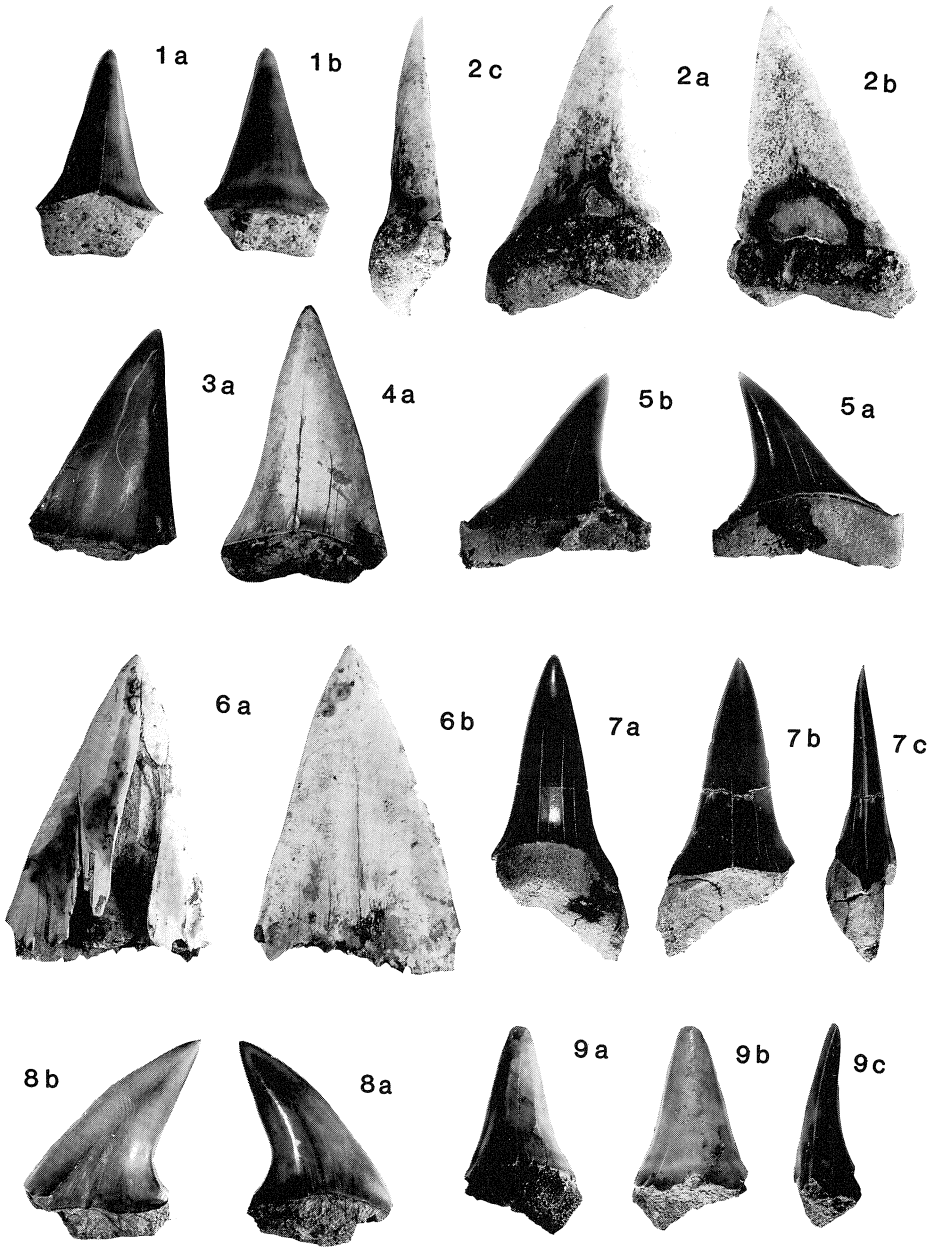
Figures 8, 9. *Isurus planus* (Agassiz, 1856).

Figure 8. KUE0053 : Lateral tooth, Loc. 7.

Figure 9. KUE0050 : Anterior tooth, Loc. 5.

(a : Lingual view, b : Labial view, c : Lateral view)

Plate III



Explanation of Plate IV

All figures in natual size otherwise stated.

Figures 1-7. *Isurus planus* (Agassiz, 1856)

Figure 1. KUE0051 : Lateral tooth. Loc. 1.

Figure 2. KUE0049 : Lateral tooth. Loc. 6. x. 1.5.

Figure 3. KUE0054 : Lateral tooth. Loc. 6. x 1.5.

Figure 4. KUE0093 : Lateral tooth, Loc. 7.

Figure 5. KUE0052 : Lateral tooth, Loc. 11.

Figure 6. KUE0094 : Lateral tooth, Loc. 6.

Figure 7. KUE0055 : Lateral tooth, Loc. 7. x 1.5.

Figure 8. *Isurus oxyrhinchus* Rafinesque, 1810.

KUE0103 : Lateral tooth, Loc. 14.

Figures 9, 10. *Carcharodon carcharias* (Linnaeus, 1758).

Figure 9. KUE0101 : Loc. 14.

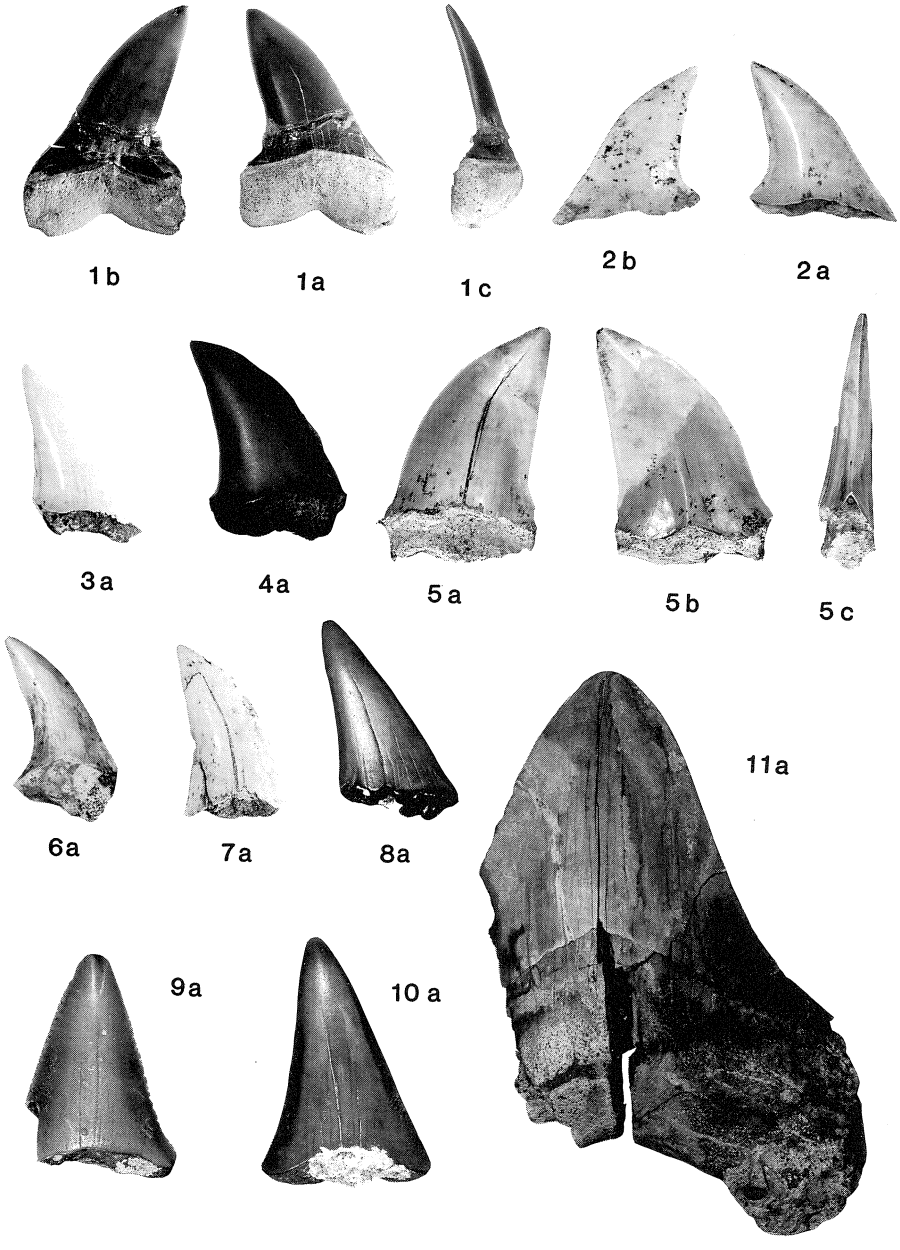
Figure 10. KUE0102 : Loc. 14.

Figure 11. *Carcharocles megalodon* (Agassiz, 1843).

KUE0095 : Loc. 9.

(a : Lingual view, b : Labial view, c : Lateral view)

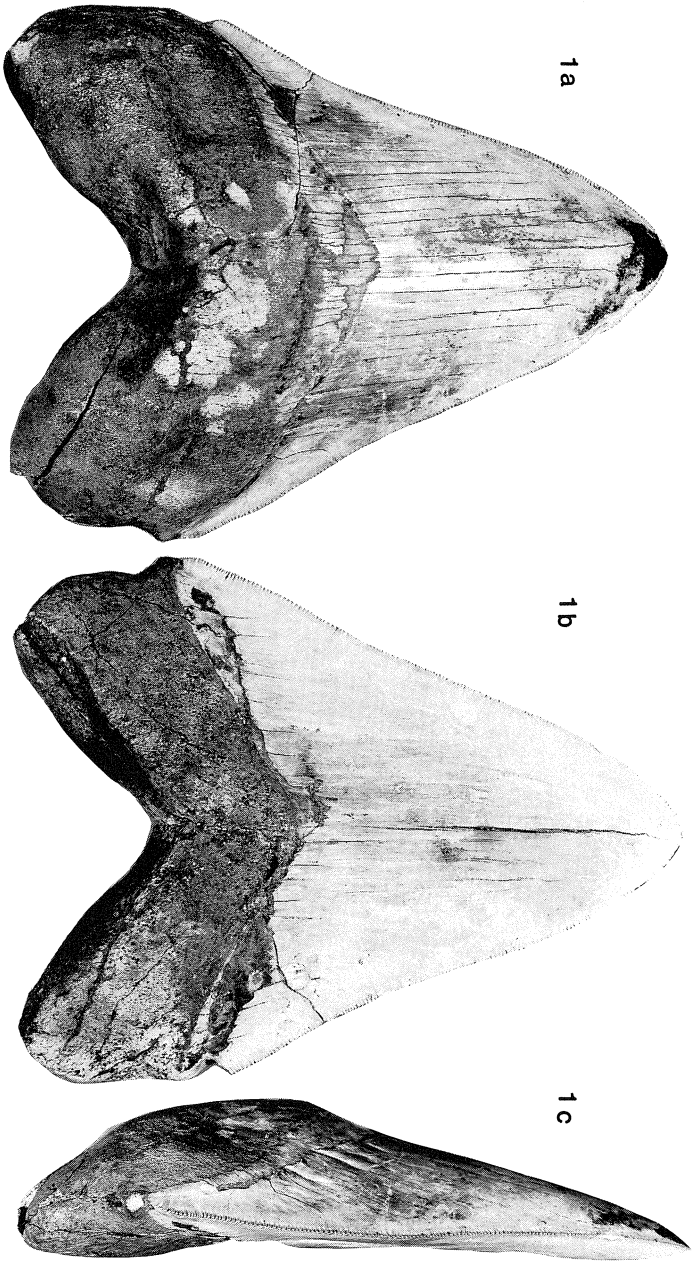
Plate IV



Explanation of Plate V

Figure 1. *Carcharocles megalodon* (Agassiz, 1843). x 0.8.
KUE0034 : Upper anterior tooth, Loc. 12.
(a : Lingual view, b : Labial view, c : Lateral view)

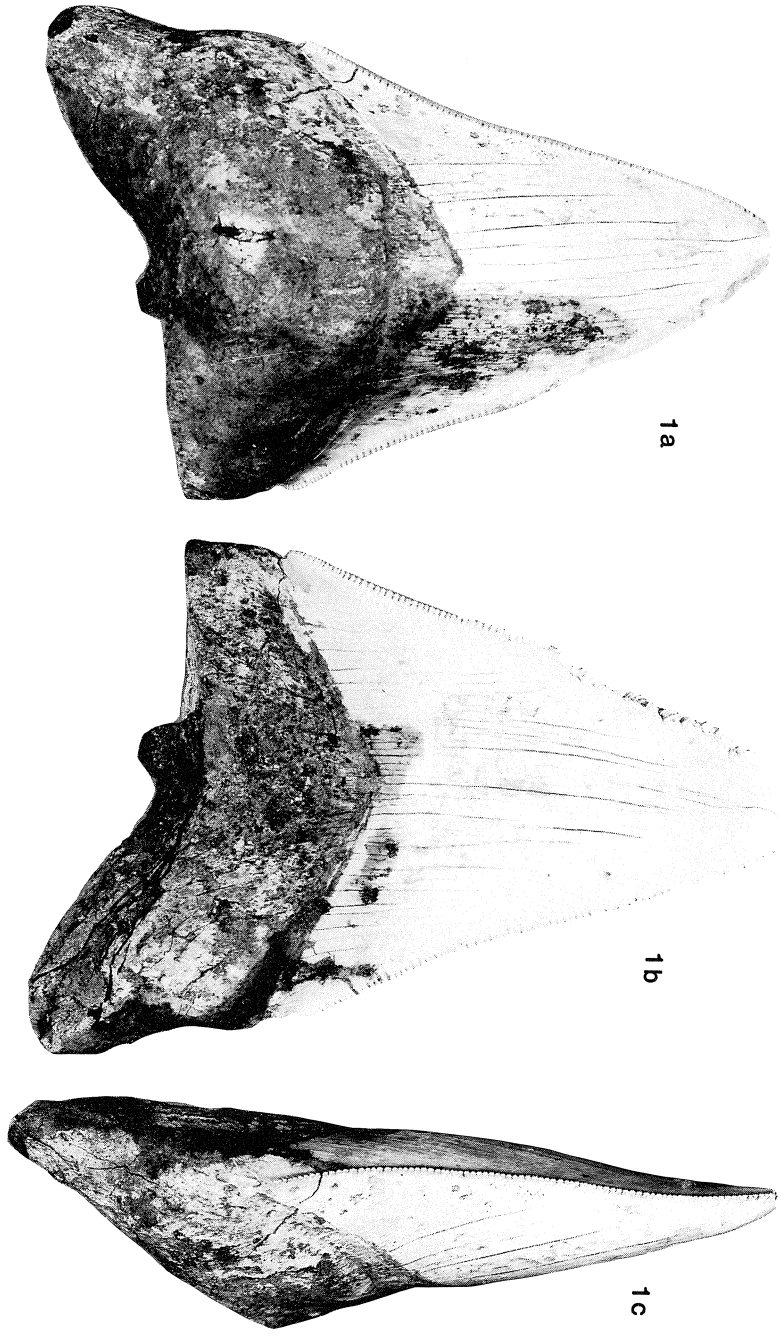
Plate V



Explanation of Plate VI

Figure 1. *Carcharocles megalodon* (Agassiz, 1843). x 1.0.
KUE0035 : Lower anterior tooth, Loc. 12.
(a : Lingual view, b : Labial view, c : Lateral view)

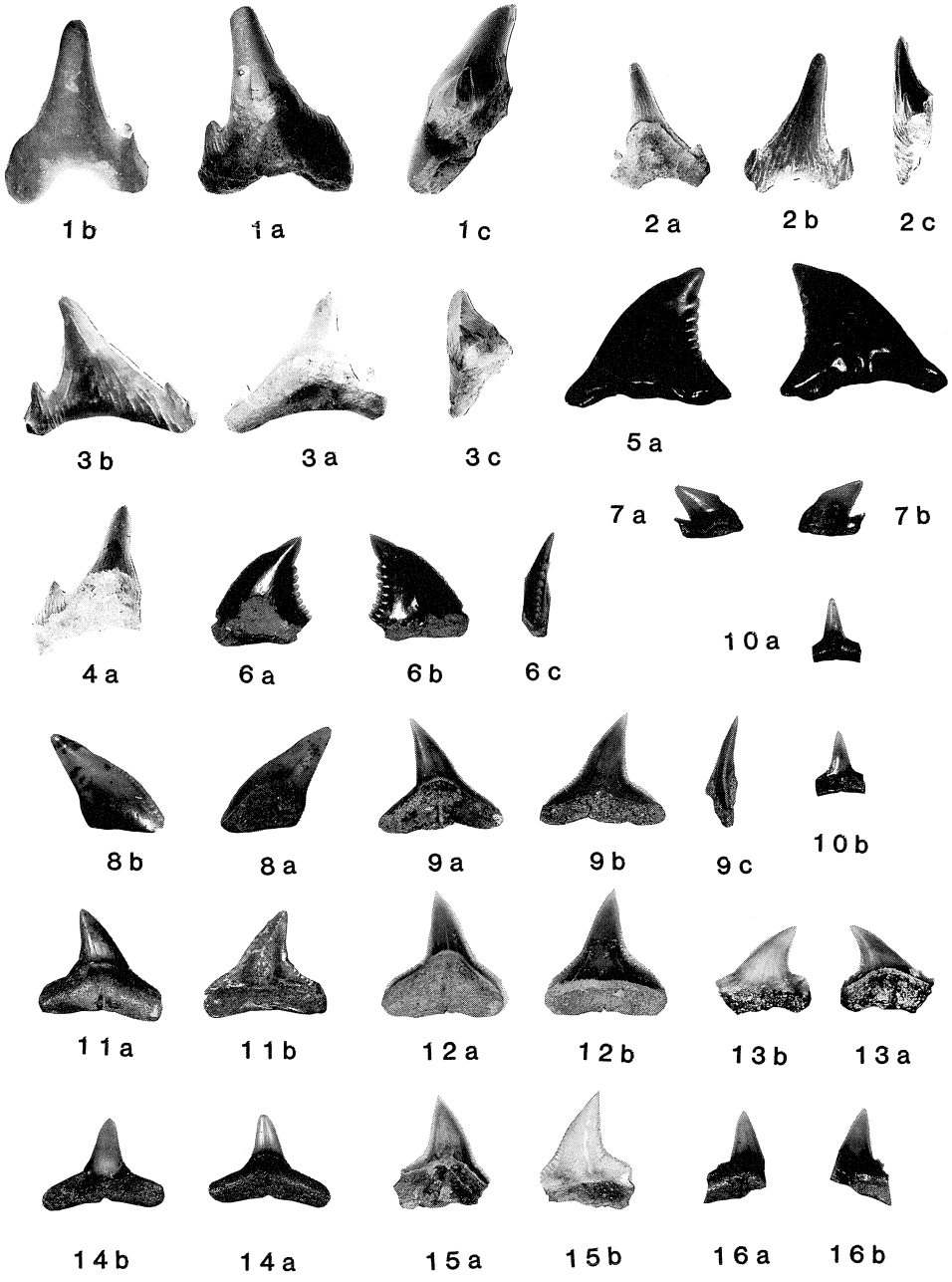
Plate VI



Explanation of Plate VII

Figures 1-4. *Scyliorhinus kasenoi,* nov. sp. x 15.
Figure 1. KUE0002 (Holotype) : Loc. 7.
Figure 2. KUE0003 (Paratype-1) : Loc. 7.
Figure 3. KUE0004 (Paratype-2) : Loc. 7.
Figure 4. KUE0005 : Loc. 7.
Figures 5, 6. *Hemipristis serra* Agassiz, 1843. x 1.5.
Figure 5. KUE0070 : Upper tooth, Loc. 3.
Figure 6. KUE0022 : Upper tooth. Loc. 11.
Figures 7, 8. *Galeocerdo aduncus* Agassiz, 1843. x 1.5.
Figure 7. KUE0065 : Loc. 3.
Figure 8. KUE0098 : Loc. 3.
Figures 9-11. *Carcharhinus priscus* (Agassiz, 1843). x 1.5.
Figure 9. KUE0007 : Upper tooth, Loc. 1.
Figure 10. KUE0008 : Lower tooth, Loc. 3.
Figure 11. KUE0009 : Upper tooth, Loc. 3.
Figures 12-15. *Carcharhinus egertoni* (Agassiz, 1843). x 1.5.
Figure 12. KUE0010 : Upper tooth, Loc. 7.
Figure 13. KUE0011 : Upper tooth, Loc. 3.
Figure 14. KUE0012 : Lower tooth, Loc. 7.
Figure 15. KUE0013 : Upper tooth, Loc. 3.
Figure 16. *Carcharhinus acanthodon* (Le Hon, 1871). x 1.5.
KUE0023 : Loc. 3.
(a : Lingual view, b : Labial view, c : Lateral view)

Plate VII


1b
1a
1c
2a
2b
2c
3b
3a
3c
5a
7a
7b
4a
6a
6b
6c
10a
8b
8a
9a
9b
9c
10b
11a
11b
12a
12b
13b
13a
14b
14a
15a
15b
16a
16b

Explanation of Plate Ⅷ

Figures 1-3. Carcharhinidae, gen. et sp. indet. x 1.0.

Figure 1. KUE0019 : Vertebra, Loc. 13.

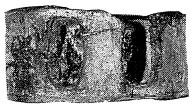
Figure 2. KUE0020 : Vertebra, Loc. 13.

Figure 3. KUE0021 : Vertebra. Loc. 13.

(a : Cranial or caudal view, b : Dorsal view, c : Vental view, d : Lateral view)

Plate VIII

1 b



2 b

3 b

1c

2 c

3c

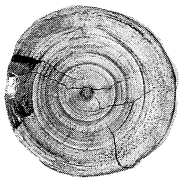
1d

2 d

3d

1a

2a



3a