Office of Road Inquiry: Experiments in road engineering.

Office of Experiment Stations: Collection and dissemination of information regarding agricultural education and research in the United States and other countries. Supervision of coöperative investigations on the food and nutrition of man and on irrigation. Investigations on the agriculture of Alaska.

The Library: Contains 63,144 volumes, largely on agriculture and agricultural science. The library is engaged in the preparation of bibliographies of subjects in agriculture and agricultural science.

Publications: During the year ended June 30, 1898, the Department issued 501 bulletins and reports, the total number of copies being 6,280,365, exclusive of the Yearbook, which has an edition of 500,000 copies, and also of the publications of the Weather Bureau.

A. C. True.

THE BREEDING OF ANIMALS AT WOODS HOLL DURING THE MONTHS OF JUNE, JULY AND AUGUST.

During the month of June the temperature of the water continues the regular increase which begins on the first of April, and toward the end of the month reaches the temperature of 65° F. During July of the present year it fluctuated between 66° F. and 71° F., and during August it frequently registered 72° F.

With the increased temperature of the month of June there is a corresponding increase in the number of breeding animals; indeed, this month indicates the culminating point of reproductive activity of marine organisms at Woods Holl. The months of July and August are characterized by a constantly decreasing number of breeding animals, though the high temperature of the water is conducive to the rapid growth of innumerable larvæ.

Vertebrates.—Breeding lampreys have been taken at East Taunton as late as June 17, and the eggs hatch in from eleven to fourteen days. The smooth dog-fish, *Galeus canis*, frequently gives birth to 'pups' while confined in the 'fish cars' during this month. These young, beautifully marked, swim about with their parents, and do not seriously suffer from their restricted quarters. The fishermen say that the 'smooth dog' has two broods, and the observations made at the laboratories would indicate that this view is correct. The first brood is generally dropped during the early part of June, though during the latter part of the month a few females are often found with fully developed young. It is probable that, as soon as the young are born, mature eggs leave the ovary and pass into the oviduct, where they become fertilized. Professor W. A. Locy has removed eggs from the oviduct, which were in segmentation stages, from as early as June 22 to as late as July 4. Through the early part of July the embryos are small, but during August only advanced stages are found. The second brood may be dropped as early as August 10th.

The belief that the females after giving birth to their first brood immediately breed again is supported by Dr. Ayers, who has noted that there are congested placental spots on the uterine walls of individuals, the oviducts of which contain active spermatozoa, and Dr. Locy has noted that the ovaries contain certain large ova during June, whereas they contain only smaller eggs after the early part of July. No individual, however, is actually known to have given birth to two broods in a single summer.

The sand shark, *Carcharias littoralis*, the most common shark at Woods Holl during the summer, so far as I know, has never been taken during the breeding season, all the individuals being apparently immature. The spiny dog-fish, *Squalus acanthias*, though at times abundant during the early spring, has not been taken in sufficient numbers during recent summers to be of special value. Those desirous of collecting embryological material of this species have generally gone to North Truro, Province-

town or Lanesville. During the latter part of June segmentation stages and early embryos are found. During July embryos of about 1 cm. prevail. Early in August the embryos have reached a length of about 2 cm., and during the latter part of August embryos from 3 to 7 cm. in length are most abundant.

The common skate, *Raja erinacea*, is abundant during June, July and August, and at times fully a bucketful of eggs have been deposited in the 'fish cars' in a single night. The ripe females may be distinguished by the color of the lower side of the abdomen, through the thin walls of which the ova may be felt and even seen. Torpedoes with ripe eggs have not been taken. The short-nosed sturgeon, *Acipenser brevirostis*, is occasionally taken in June, the females bearing ripe eggs. The menhaden, *Brevoortia tyrannus*, breeds during the month of June, though no young were taken the present year. By the middle of July schools of young fish of about one inch in length are often to be seen.

Fundulus majalis continues its breeding during June and early July, and its eggs may be artificially fertilized with the sperm of *Fundulus heteroclitus*. The latter species breeds abundantly from the middle of May until the middle of July, but during the latter part of July and the first of August only a few ripe eggs can be secured. *Cyprinodon variegatus* spawns in June. *Lucania parva* is said to be viviparous. I do not know when it breeds. I am informed that late in July the female pipe-fish bears large ovarian eggs, and the males are still carrying embryos in their brood-pouches. Late in August both embryos and pouches have disappeared, and the ovaries contain only immature eggs.

Two species of *Menidia* (*gracilis* and *notata*) abound in the neighborhood of the laboratories. The following has been taken from notes kindly furnished by Dr. C. Judson Herrick: On June 5, 1896, Mr. Edwards found *Menidia notata* spawning at Hyannis in vast numbers. At this time the fish had selected a point in the beach grass above the low-tide level, and at low-tide the eggs were consequently exposed to the sun and dried. Mr. Edwards noted great quantities of spawn and milt, and collected about a quart of the former. During the last days of June and the first ten days of July of the present year the fish were very scarce, though Dr. Herrick found a few ripe females and a very few males. The eggs adhere to each other in thick ropy masses, and to any foreign object with which they come in contact, by means of long threads. Both fertile and unfertile eggs sink to the bottom, and the first cleavage plane appears in about one hour. The eggs may be artificially hatched in jars of running water, the period of incubation being ten days. The young fish, which carry a small yolk-sac, are about 6 mm. in length. Fry were skimmed from the surface of the harbor on July 4th, and measured 1.5 cm. in length. On July 9th fry similarly taken measured 2.25 cm. in length.

The eggs of *M. gracilis* resemble those of *M. notata*, but the species seems to breed later, since many ripe females were taken during the first week in July. The eggs, however, do not undergo artificial fertilization as readily as those of the first species.

The mackerel, *Scomber scombrus*, breeds during the middle and latter part of June, and generally at some distance from the shore. During the early part of the month of August of the present year myriads of young fish, about two inches in length, were found in the southern portion of Massachusetts Bay, showing that the breeding had taken place much nearer the shore than is usual. The butter-fish, *Rhombus triacanthus*, breeds during June. The white perch, *Morone americana*, breeds in May and June, and the sea-bass, *Centropristes striatus*, from

the middle of May to near the first of July. The scup, *Stenotomus chrysops*, spawns during early June, but the eggs do not all become ripe at the same time. Though thousands of squeteague were taken in the fish-trap during July, not a single individual contained spawn, and this was not surprising, for, according to Dr. Hugh M. Smith' spawning occurs about June. The cunner, *Tautogolabrus adspersus*, spawns during June and early July, and the bright colored young are abundantly found throughout the latter part of the summer. Ripe tautog, *Tautoga onitis*, were 'stripped' on June 15th and ripe eggs might have been taken until' the middle of July. The 'puffers' are also summer breeders, the spawning season occurring early in June, after which the young are frequently taken in the skimming-net.

Since the establishment of the biological laboratories at Woods Holl the toad-fish has contributed to science with great generosity. Tin cans, broken bottles and shattered fragments of crockery are regularly planted by the collectors, and are regularly lined with large golden eggs. Oviposition occurs as early as June 3, and it may occur at any subsequent time throughout the month. According to Dr. Hugh M. Smith the blue-fish arrives about June 1st, at which time well-developed ova are found in a small proportion, and at Nantucket large roes have been found as late as July 15th. The first young blue-fish were taken at Woods Holl on June 10th, and measured from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length. The young of the mullet, *Mugil curema*, $1\frac{1}{4}$ inches in length, were taken on June 28th. Both species of sea-robin breed during the early part of June. The eggs, not particularly transparent, readily develop in the laboratory and hatch in about five days. After the first of July females with eggs are seldom taken.

Among the Pleuronectidæ, *Bothus maculatus* breeds during early June, and the eggs may be artificially hatched, the period of incubation being about eight days. The young of 'flat-fish' were taken in the tow-net by Mr. S. R. Williams, from the 4th to the 17th of June, on which latter date they were most abundant. A few were also taken during the latter part of the month and during July. I have the following interesting note from Mr. Vinal Edwards: "A large school of young cod placed in the 'Eel Pond' directly from the hatching jars, in December last, left the pond in June when the water reached a temperature of about 60° F. They were at this time from 2 to $4\frac{1}{2}$ inches in length." The spawn of the goose-fish is occasionally taken near Menimsha. When a spawn is found, an abundance of embryological material results, since the eggs are united in a great jelly-like band that will more than fill a bucket.

The auftrieb is not rich in surface vertebrates during the summer. In June young hake, pipe-fish, lump-fish and herring occasionally occur. In early July young swell-fish, cunners, sticklebacks, tautog, sand-eels, silversides, hake and sand dabs; and during the middle of July the swell-fish, cunners, sticklebacks, silversides, sand-eels and hake are still conspicuous, though gradually disappearing from the surface as the season advances. By the middle of August only occasional specimens are taken.

Two species of land turtles are abundant in fresh-water ponds near the laboratories. The painted turtle, *Chrysemys picta*, breeds from June 11 to 25, and deposits its eggs in the evening, from 6 to 8:30 o'clock. The snapping turtle also breeds during the middle of June, but it deposits its eggs in the early morning.

Ascidians.—I am indebted to Frank W. Bancroft for many of the following notes respecting the breeding of ascidians.

Appendicularia were abundant near Gay Head on July 28th, and *Doliolum* is often taken at the same locality. Farther from

the shore several species of *Salpa* occur in abundance.

Among the simple ascidians, *Molgula* may be obtained in abundance from the woodwork in the harbor of New Bedford, and I think the eggs are ripe throughout the summer. *Cynthia partita* is apparently ripe throughout the month of July, at which time Dr. Bancroft also found ripe *Ciona intestinalis* and *Perophora viridis*.

Among the composite ascidians, *Botryllus gouldii* was found breeding from the sixth to the end of July, and almost all the older colonies contained either large ova or embryos. This species was not examined before the sixth, nor after the close of the month. Though several colonies of *Amaræcium stellatum* were examined, no large eggs or embryos were found during July, although *A. constellatum* frequently had large ova and embryos.

Crustacea.—There are several Brachyurans that carry eggs during the summer months. *Gelasimus minax, pugnax* and *pugilator* breed during the early parts of June, and females with eggs occur as late as July 2d, and perhaps later. *Sesarma reticulata* I frequently have found with eggs, but no specific data are at hand. *Pinnixa cylindrica* was found with eggs on July 13. *Pinnotheres maculatus* has been studied by Mr. F. P. Gorham, who found that the animals were very active at night, leaving the seclusion of the mantle-chamber of the mussel, and swimming and crawling about in the water in a most restless manner. On July 9 eggs in the earliest stages of development were taken, and from then until August 29 Mr. Gorham found all stages, though at the latter date egg-bearing females were relatively less abundant. *Panopœus* was found with eggs on June 7, and gastrulation stages were found on July 1. On July 8 all stages from four cells to complete embryos were noted, and on July 12 two females deposited eggs while in captivity. *Carcinus granulatus* was found with eggs, in late stages, June 25. *Platyonichus ocellatus* carried late stages on July 3. *Callinectes hastatus* was found with advanced embryos on August 3. *Libinia* has been seen to oviposit as late as August 7. *Pelia mutica* bears beautiful transparent eggs, which are in early embryonic stages the first week in July.

Among the Anomoura, *Hippa talpoida* carries eggs in the latter part of June and throughout the month of July. Mr. Gorham found early embryos and free-swimming young on August 9, 1896, and the characteristic Zoea are conspicuous in the skimmings throughout the month of August, being most abundant on the 22. Mr. M. T. Thompson found *Eupagurus longicarpus* with eggs until the middle of September. *E. annulipes* was not brought to the Laboratory before the early part of September, but at that time the females had eggs in varying stages of development. The breeding habits of *E. bernhardus* and of *E. pollicaris* were not noted, though the skimmings yielded an abundance of Zoea from the first of August throughout the month, and were probably present still earlier. The 'Glaucothoe stage' was first found on the 12th of August, and was frequent thereafter throughout the month.

Zoea of various species are conspicuous in the surface material from the first week in June, and Mr. S. R. Williams noted that when they were abundant they seemed to exclude 'Megalops' and *vice versa*.

Among the Macroura, *Gebia affinis* was found with advanced eggs on July 25. These hatched on August 7. *Callianassa stimpsoni* was found with eggs on July 1, and again on July 13. On the latter date the eggs were in segmentation stages. On July 18 other specimens bore advanced embryos which hatched on July 21. Dr. F. H. Herrick for several years had the opportunity of examining many

lobsters at the Fish Commission Hatchery, and concluded that the larger number of eggs were laid during the latter half of July and the first two weeks of August. These eggs are normally carried by the female until the following spring, when they hatch during May, June and July. I regret that I have no specific data on the breeding habits of *Crangon vulgaris*, but I have every reason to suppose that it is bearing and hatching eggs with its characteristic industry. Mr. F. P. Gorham found *Virbius zostericola* carrying eggs in all stages of development from the first of June to the first of September; the period of incubation lasts for about two weeks. *Palæmonetes vulgaris* was found with eggs in early stages of segmentation on June 20, and on the same date other individuals were found bearing late blastoderm stages and fully-formed embryos. The larvæ of *Palæmonetes* are excessively abundant in the auftrieb during July and August. The young of *Squilla* was occasionally taken in the tow-net during August, and was abundant on the surface of the Gulf Stream. A beautiful *Heteromysis*, bearing deep green eggs, was frequently dredged on the shelly bottom east of Nobsque during June and July. The young of *Cuma* were taken in the skimmings on June 14.

The Amphipods are by no means as abundant as during the spring. Mr. F. M. Watson found *Amphithoë compta* breeding through July and the first week or two of August and *Calliopius lævisculus* with eggs on August 1. *Orchestia agilis* was represented by innumerable young during the first two weeks in July; *Podocerus falcatus* was taken with eggs during the last two weeks of July and the first two weeks of August. Early in August a large number of Caprellæ bearing eggs were taken. *Talorchestia* has been found with eggs in late stages of development on June 14, and *Orchestia agilis* with eggs and embryos on June 20. A tube-dwelling amphipod, probably *Cerapus tubularis*, bears eggs, some of which are in early stages of development on July 4. *Hyperia* is frequently taken during June, and its large, almost absolutely transparent eggs would form excellent material for certain lines of biological research.

Among the Isopods, *Idotea robusta* was found with eggs on July 17, and again on August 12. Dr. J. P. McMurrich has found *Jæra marina* breeding in the middle of June, when his first observations were made, and from then without interruption until the first week in September, the time of his departure from the laboratory. *Tanais vittatus* was found with eggs in various stages of development early in August, and Dr. W. M. Wheeler has found the eggs of *Armadilidium vulgare* around old logs at Butler's Point late in June.

Copepods are, of course, abundant in all the surface material, and the parasitic Copepods found attached to the various fishes almost invariably bear egg-capsules which contain embryos in various stages of development. Attached to the floating seaweeds, boards, etc., which are washed on to the shore from the ocean are two or three species of 'goose barnacle,' which yield abundant embryonic material.

Dr. Wheeler found *Limnetis gouldii* breeding in small fresh-water onds on Penzance, June 6–13, 1892. Associated with these were many specimens of *Eulimnadia agassizii* and *Bosmina*, both sexually mature.

The Pycnogonids breed during July, August and September. Dr. T. H. Morgan has recorded the appearance of *Tanystylum orbiculare* with eggs on July 1st; *Pallene empusa* carries eggs throughout the summer, and *Phoxichilidium maxillare* during August and September.

Limulus was found depositing eggs on June 19, and eggs were artificially fertilized on July 12, though the females were then nearly spent.

Vermes.—The breeding season of *Lepidonotus* and *Harmothoë* has passed. The eggs of *Sthenelais* may be artificially fertilized, and ripe individuals have been taken during the middle and latter part of August. *Podarke obscura* begins to oviposit about July 1. Dr. A. L. Treadwell has succeeded in artificially fertilizing the eggs by keeping the males and females in separate dishes until the sexual products are extruded, and then mixing in the ordinary way. *Autolytus* and other Syllids are frequently taken in the skimmings; the eggs are held in small spheres under the abdomen. *Nereis limbata* and *N. megalops* may be taken at the surface, in the evening, in great numbers and during the entire summer. The breeding habits of *Diopatra* are unknown, though the ova are nearly ripe in August. Though many specimens of *Marphysa* have been collected, the time of sexual maturity is not known. The breeding habits of *Anthostoma* and *Trophonia* are also unknown. Dr. A. D. Mead informs me that *Cirratulus grandis* breeds during July, and that the females will deposit their eggs while in confinement. The eggs are of fair size, but very opaque. Oviposition takes place in the evening. On the breeding habits of *Maldane* and *Cistenides* I have been unable to collect specific data.

Dr. Mead has spent a great deal of time in determining the breeding period of *Amphitrite ornata*, and after collecting about eight hundred specimens, at various times of the year, concludes that there is no definite breeding season. Between the first of June and the last of August only occasional individuals were found which yielded ripe sexual products. The eggs are extruded during the evening, and will not fertilize if artificially removed from the body cavity. *Scionopsis palmata* was found to bear eggs, apparently ripe, in August, but artificial fertilization was not attempted. The eggs of *Serpula* (*Hydroides*) may be readily secured by simply crushing the worm-tubes, and then placing the somewhat injured female in sea-water. As soon as the males are taken from the tubes the sperm will be seen to ooze from the nephridial openings. *Spirorbis borealis* is frequently found with eggs and embryos. From the latter part of June to the latter part of July the eggs of *Arenicola* may be collected by the bucketful. They are extruded in a jelly-like mass, sometimes two feet in length, and are especially abundant on the warm sand-flats of Buzzard's Bay.

Dr. Mead obtained the eggs of *Chætopterus* during July and August by cutting open the females. During the early summer of 1892 the larvæ of *Polygordius* were exceedingly abundant, and few specimens were taken during the past summer. *Sagitta* occurred occasionally. It was noted by Mr. S. R. Williams during the middle of June, and again at the close of the month and early in July.

Nectonema was occasionally brought into the Laboratory, and Dr. H. B. Ward has known it to extrude its eggs while in dishes of sea-water.

Dr. E. G. Gardiner informs me that he has taken the orange-colored eggs of *Polychærus caudatus* as early as June 6, and that they are abundant from June 15 to August 25. The eggs are deposited at night in transparent gelatinous capsules.

'Tornaria' larvæ are often taken during August in great abundance at flood tide, during both day and night.

Echinoderms.—Previous notes in SCIENCE have called attention to the early breeding habits of several representatives of this group. *Echinarachnius parma* continues to breed throughout June and the early part of July, and a limited number of eggs may be secured even during the later portions of the summer. *Arbacia punctulata* yields ripe eggs during the latter part of June, throughout July and a portion of August.

Strongylocentrotus was not carefully examined, though at Nahant I have often noted the extrusion of the yellowish, opaque eggs at various times during the warmer months.

The breeding habits of the star-fish are peculiar. Dr. A. D. Mead has found the breeding period to culminate in Narragansett Bay during the last week of June, although at Woods Holl no considerable number reached sexual maturity at any time during the past summer. In 1892 larvæ were abundant on June 18.

Mr. Caswell Grave paid particular attention to the Ophiurids during the past summer, and was successful in getting many ripe specimens of *Ophiopholis aculeata* at Nahant during the month of June. These he brought to the Laboratory in sea-water, artificially cooled, and they deposited their eggs and sperm between eight and nine o'clock in the evening of the day they were collected. The development was slow, the 'pluteus stage' being reached not until three weeks after fertilization, and several of the plutei lived to be thirty-three days old without showing signs of metamorphosis. Mr. Grave followed the development of the sexual glands of *Ophiura olivacea* with great care from the first of June, but the period of sexual maturity was not reached until the second week of July, when a limited quantity of fertilized ova was obtained. The larvæ proved to be quite different from those of any previously described Ophiuran. *Thyone briareus* and *Synapta inhærens* (= *Synapta girardii*) probably breed during June and July. I think the eggs have never been artificially fertilized. Echinoderm larvæ, which may have been brought to Woods Holl by currents, were abundant during the middle of June. Brachiolaria swarmed in Narragansett Bay from the last of June to the middle of July.

Mollusks.—During the first week of June the young of *Mytilus*, the 'sand-collars' of *Lunatia*, the 'eggs-strings' of *Sycotypus* and the 'egg-capsules' of *Urosalpinx* were noted in Narragansett Bay. During the second week of June, *Crepidula*, *Urosalpinx* and several naked Mollusks were found ovipositing. Dr. F. R. Lillie has collected eggs of *Pecten* from July 10 to August 4. On August 17 the breeding period had passed. According to Dr. Conklin the breeding period of *Crepidula fornicata* lasts from early summer until about August 15. The breeding period of *Crepidula plana* is somewhat later and longer, and newly laid eggs were found September 7. *Crepidula convexa* lasts through much the same period as *C. plana*. Dr. Lillie says that the unsegmented ova of *Unio complanata* can be obtained from about the middle of June to the middle of July, those of *Anodonta* toward the end of July and early in August. The 'Glochidia' of *Unio* escape in August and September, and the eggs of *Anodonta* are carried by the mother through the winter and are extruded in the spring.

Small squid were taken on the surface from June 20 to the close of the summer.

The clam, *Mya arenaria*, breeds during June and perhaps earlier. The height of the breeding season of the oyster is during the latter part of July, and the development is so rapid that the young swim in less than six hours after fertilization.

Mr. S. R. Williams, who kept a record of the surface forms during the past summer, found 'veligers' abundant on June 12, July 9 and July 19.

Cœlenterates.—*Cyanea arctica* has been taken with ripe eggs as late as June 3, though by the middle of the month only occasional specimens are seen. The eggs readily fertilize, and the young develop freely in the aquaria. The 'Ephyræ' of *Aurelia* were taken in the tow on June 15. The Scyphomedusæ are not abundant at Woods Holl during mid-summer, an occasional *Dactylometra* or an immature *Cyanea* being almost the sole representative of the

group. At New Bedford, and in Narragansett Bay, *Dactylometra* is excessively abundant, and one would probably have little difficulty in getting material for embryological study at almost any time. *Metridium* has frequently been seen to extrude its eggs, which may be artificially fertilized, and *Sagartia* has also been found breeding during the middle of July.

I am indebted to Professor W. C. Hargitt for many of the following notes on the breeding of Hydroids:

Clava leptostyla.—Colonies are occasionally taken from rock-weed in the 'Hole,' from June 18 to the end of the month, and less frequently throughout the summer. Colonies may also be taken from exposed timbers under the wharf of the U. S. Fish Commission. The male colonies are much more abundant and conspicuous.

Clytia bicophora, on the shells of *Mytilus*, with colonies of *Eudendrium*, is abundant late in June, when it is in a thrifty condition, and with mature gonangia.

Eudendrium. — Colonies of *Eudendrium*, probably *E. ramosum*, were taken in very imperfect condition June 17, apparently just beginning development from old stolons. Specimens were also taken from under the culvert at the outlet of the Eel Pond, on June 20, in a more vigorous condition, but with only male gonophores, which contained ripe spermatozoa. Colonies developed rapidly during the following ten days and produced female gonophores. The earliest signs of development of eggs occurred during the first week of July. The latest were recorded by Dr. Murbach, on September 15.

Corynitis Agassizii.—Specimens taken from the wharves of the Fish Commission on June 20, on shells of *Mytilus*, were in a thrifty condition and bore mature medusæ. These are set free during the early evening, and swim actively about the aquarium, though at this time there are no indications of sexual products. Several colonies of this interesting Hydroid were taken, but always from the encrusting deposit of a Bryozoon, which frequently occurs on the shells of *Mytilus.*

Hydractinia (Echinata) polyclina.—Colonies taken from the shells of Eupagurids, from rock-weed and from *Limulus*, were mostly sterile in June, or with only male gonads. It breeds during July and August.

Margelis carolinensis is quite common and in an excellent state of growth during June, though without medusa-buds. It is found on the timbers of the Fish Commission docks, on rock-weed and occasionally upon eel-grass. It breeds during August.

Obelia sp.—A species of *Obelia* is very abundant along the rock work and wharves, and during June develops apparently ripe gonangia, though few free medusæ.

Parypha crocea.—In splendid profusion and perfection throughout the month of June.

Pennaria tiarella.—During the month of June this species is to be found in limited numbers attached to rock-weed and to the piles of the wharves. Its development is slow, specimens with medusa-buds not being taken until June 29. During the following weeks the development is more rapid, both of the polyp-stock and of the medusæ. Dr. Murbach has found the species breeding as late as September.

Sertularia sp.—Everywhere in abundance, but with gonangia only in a few cases. Several species are found, of which the commoner are *Pumila* and *Argentea.*

Dr. McMurrich found *Laomedea amphora*, on Fucus, with ripe gonophores, June 2, and associated with it was *Halecium*, in a similar sexual condition. During the latter part of June and throughout the summer the medusæ of *Gonionemus* is found in great quantities in the Eel Pond. Mr. Williams noted *Clytia* and *Lizzia* in the sur-

face fauna during the second week of June, and medusæ of *Eucope* were found at various times during the summer. On July 28 an undetermined species of Hydromedusa was so abundant at Menimsha that a tumbler simply dipped into the ocean would be more than half filled with them.

Dr. Murbach has found *Corynitis* breeding during July and the early part of August, *Podocoryne* and *Hypolytus* during August.

Ctenophores, frequent during the early part of summer, literally swarm during the latter part of August. *Mneniopsis* is the most abundant species.

H. C. Bumpus.

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*AN AMPERE BALANCE.**

The Report of the Committee on Electrical Standards for 1897 ended with the following paragraph: "It thus appears to be a matter of urgent importance that a redetermination of the electro-chemical equivalent of silver should be made and that the general question of the absolute measurement of electric currents should be investigated * * *" This work we were asked by the Committee to carry out, and a grant of £75 was voted in its aid. We were thus led to examine into the methods which had been employed by Lord Rayleigh, Professor Mascart and others, for determining the absolute value of a current, as well as to consider some other methods which have not, as far as we know, been hitherto used.

After much consideration we decided to adopt a form of apparatus which, while generally resembling the type employed by some previous experimenters, possessed certain important differences; and, before expending any part of the grant of £75, to construct, without expense to the British Association, the following preliminary Ampere Balance.

On a vertical cylinder about 17 inches high and 6.8 inches in diameter we wound two coils, about 5 inches in height, separated by an axial distance of 5 inches. The coils consisted each of a *single* layer of about 170 convolutions of wire and were wound in opposite directions. From the beam of a balance there was suspended, inside this cylinder, a light bobbin about 4 inches in diameter, on which was wound a coil about 10 inches long, consisting of a *single* layer of 360 convolutions, and the whole apparatus was so adjusted that when the beam of the balance was horizontal the inner and outer coils were coaxial and the top and bottom of the inner suspended coil were respectively in the mean planes of the outer stationary coils.

This arrangement was adopted because with coils consisting of only one layer the geometrical dimensions could be accurately determined, and because the shapes of the coils lent themselves to the use of the convenient formula, readily expressible in elliptic integrals, for the force, F, between a uniform cylindrical current sheet and a coaxial helix, viz:

$$F = \gamma\gamma_h(M_1 - M_2),$$

where γ is the current per unit length of the current sheet, γ_h the current in the helix, and M_1 and M_2 the coefficients of mutual induction of the helix and the circular ends of the current sheet.*

The value of a particular current of about 0.63 ampere having been determined *absolutely* by means of this apparatus, the rate at which it would deposit silver under specified conditions was ascertained indirectly, by observing its silver value on a Kelvin balance which had been kept screwed down in a fixed position for several years past and which had been calibrated many times

* Read before the British Association.

* Proceedings of the Royal Society, Vol. 63, "On the Calculation of the Coefficient of Mutual Induction of a Circle and a Coaxial Helix, and of the Electromagnetic Force between a Helical Current and a Uniform Coaxial Circular Cylindrical Current Sheet," by Professor J. V. Jones.