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Report of SCOR working group III on the questionaire regarding plankton nets in use in various laboratories.

by

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INTRODUCTION

During the third meeting of SCOR held in New York on the 29th and 30th August and on the 12th September 1959, the working group on biology met to further consider a biological programme for the projected International Indian Ocean Expedition, then scheduled for 1962 and 1963. One aim of these discussions was the recommendation of standard gear and methods to be used by all ships concerned with biological work during these cruises.

The advantage of such a recommendation will be obvious to all who have been concerned with the operation of gear and with the interpretation of the data from different nets. Too often it is the case that the gear and methods used are so different as to make comparisons impossible except by invoking conversion factors, often of doubtful accuracy. It thus follows that in any investigation whether it be a small regional survey or a large scale oceanic expedition the use of standardised gear and methods is not only desirable but essential.

With regard to the International Indian Ocean Expedition it was felt by the working group on zooplankton methods that recommendations could only be made when details were available of the gear and techniques employed by the various workers in the different countries interested in the venture. With this end in view a questionnaire was circulated requesting that details of gear and methods be sent to Mr. N.B. Marshall of the British Museum (Nat. Hist) who was at that time the convenor of the working group on biology. It was hoped that if the response were satisfactory it would be possible to publish a review of existing gear and methods.

Recipients of the questionnaire were asked to provide detailed information on all forms of sampling gear in routine use in their investigations, including bottom and midwater trawls. Answers were received from a total of eleven Institutions or departments in eight countries as follows:-

Denmark, Danmarks, Fiskeri-Og Havundersogelser: Netherlands, Rijksinstitut Voor Visseng Onderzoek: England, The National Institute of Oceanography:

U.S.A., Woods Hole Oceanographic Institution: Bureau of Commercial Fisheries La Jolla: The Marine Laboratory, University of Miami: Department of Oceanography, University of Washington, Seattle: Australia, C.S.I.R.O. Division of Fisheries, Cronulla, N.S.W: Japan, Institute for Fisheries Investigations; Hokkaido University: Indian, University of Madras: U.S.S.R. Institute of Oceanology, Moscow. I should like to take the opportunity of thanking all who have contributed the data on which this paper is based.

The replies received varied somewhat in the detail of their information and on the basis of this relatively limited response it is unfortunately impossible to give a complete review of existing standard gear and methods. While the data is insufficient in this respect it does go some way to providing a basis for comparison allowing fundamental differences to be discussed with a view to evaluating the requirements that any Indian Ocean Standard Net must fulfill.

The data are summarised in table 1. It has been impossible to include all the gear referred to in some of the replies and indeed little would be gained from such a list since in countries and institutions where many diverse problems are being investigated so there is a vast array of sampling gear in routine use. I have thus in table 1. listed details of those nets which are most closely comparable not only in design but in the sort of sampling to which they are best suited. In compiling this table it has been necessary in some instances to augment the information given in the replies to the questionnaire by reference to published descriptions of nets and methods. To illustrate some of the differences evident from the available data I have drawn in figure 1 the outline shapes of the main types of net to scale. Again use has been made of published descriptions, particularly in the case of the Juday nets. Not all the samplers have been included in this figure, notable ommissions being the Clarke-Bumpus sampler used at Cronulla and Seattle (see table 1) Also excluded are the special plankton samplers of Professors Bogorov and Steemman Nielsen which, by enclosing large volumes of water (up to 100 litres) seek to avoid some of the sampling errors inherent in conventional townets. High speed samplers are also not included since, although their value in particular applications has been established, they

~~they~~ have yet to be adopted generally. By the omission of these samplers I do not wish to imply that they should not be considered as ~~un~~suitable for adoption as standards in the Indian Ocean sampling programme but, as I have mentioned above, my intention has been to consider these nets which are most closely comparable and which as a consequence should, one might expect, provide a basis for standardisation. Attention will be drawn in the discussion that follows to those aspects of net design and operation which are illustrated in the data presented in table 1 and figure 1 and which appear to be ~~are~~ fundamental to the problem of standardisation.

The shape of the net

From the outline shapes of the nets shown in figure 1 it is possible to distinguish three basic patterns:-

1. those of a simple conical shape e.g that used by Moore at Miami.
2. those in which a conical filtering section is preceeded by a non-filtering foresection of canvas in the form of a truncated cone. Examples are to be found in the classical Hensen egg net and in the Juday nets of the Institute of Oceanology, Moscow.

and 3. those in which the filtering section, which may be conical, is preceeded by a foresection having parallel sides, which may in part be of nylon mesh, ie. Woods Hole and the California Cooperative Oceanic Fisheries Investigations, or may be non-filtering and of canvas, ie National Institute of Oceanography.

The earliest plankton townets were almost certainly conical in shape and the second of the basic patterns described above evolved as a result of the efforts of Hensen to increase the filtering efficiency of such nets. The use of a non-filtering conical foresection reduces the the area of the mouth opening and so effectively increases the ratio between the area of the filtering section ie. the nylon mesh, and the mouth opening. The higher this ratio, for a mesh of given size, the better will be the filtration in that a greater percentage of the theoretical water column (that is mouth area x distance towed) can be accepted by the net before pressure builds up in the net and outspill at the mouth occurs. This assumes that the net is being towed at its optimum speed - see below. Ideally a net should have a filtration of 100% and early calibration tests (Kunne 1929) suggest that the Hensen net approaches this figure and there can be little doubt that such nets are an improvement on those retaining the simpler conical shape. The use of a canvas forepart of such design however introduces peculiar difficulties not the least of which is the resulting increased drag of the net particularly when paying out during which the net may in certain conditions kite in the water. In the Juday net the canvas forepart retains only a slight angle of taper compared to that in the Hensen net, and this presumably reduces the effects of drag noted above.

The NF70V of the National Institute of Oceanography has a canvas forepart with parallel sides and it will be observed that between this and the conical filtering section there is also a cylindrical section of nylon mesh. The advantage of the tapered canvas foresection compared to one with parallel sides is not clear. Sysoev (1956) has shown that the former produces a better flow while M. Roessingh (communicated in the questionnaire) states that model experiments indicate that a parallel sided section gives a better flow compared to one with a conical sedtion. Recent work at the National Institute of Oceanography (Currie & Foxton. unpublished) has shown the importance, not only of the parallel sided non-filtering section but also of the parallel sided filtering section in creating better conditions of flow in the net and reducing the possibility of outspill at the mouth.

From the available evidence one can thus only conclude that a net whose design includes a non-filtering foresection, either conical or parallel sided, is to be preferred to a net of simple conical shape. The exact form that the non-filtering foresection should take is not clear but on practical grounds the Juday and NF70V versions seem preferable to the Hensen shape which is steep sided. One concludes that there is an obvious and pressing need for fundamental rese rch into the hydrodynamics of water flow through nets before the significance of these slight differences in design can be assessed in terms of filtering efficiency.

The diameter of the net opening

The one feature common to all the net illustrated in figure 1. is that they have mouth openings of circular cross section; in no two however is the diameter the same and it is difficult to find a sensible rule with regard to this dimension. The Juday nets however are exceptions since the mouth diameters of the nets shown; 37 cm, 80 cm, and 113 cm are chosen to give cross sectional areas of 0.1 m^2 , 0.5 m^2 and 1.0 m^2 , thus facilitating computations in which the catch is considered in relation to area of sea surface or volume of water filtered.

Bearing in mind the importance of the ratio between mouth area to that of the filtering surface and the fact any change in one dimension will effect this ratio, it seems likely that the dimensions of the mouth aperture are of less importance than some of the other features of design under consideration.

Overall length of net

The need for a high filtration efficiency has been stressed and an obvious means of acheiving this, for a mouth opening of given area, is to make the net as long as possible. For any given ship, however, there will be practical limitations to the maximum length of net that can be handled with ease particularly if the net is hauled vertically. Of the nets shown in figure 1 the Juday nets, the NF70V and the Hensen nets are typical ~~of examples of~~ samplers that are hauled vertically, rather than towed horizontally or obliquely, through the water. Moreover all can be closed using a throttling technique or a modification of it. It will be apparent that universal use of large diameter long nets, for instance the two larger Juday nets, may be limited by the working height between the sea surface and the top of the derrick of davit over which they are hauled remembering that where a net is throttled by the Nansen method its overall length is increased due to the taking up of slack in the throttling rope. The NF70V for example is of such a length that it can be worked with ease from any vessel equipped with a davit of the 'Discovery type' (see [illegible] for a description). The use of a larger net however could introduce difficulties of handling, particularly after closure, if used on a davit of this type.

Such criticism does not necessarily apply to these nets if towed horizontally or obliquely since here the length of the net becomes of secondary importance to the size of mouth, weight of mouth frame etc., as a consideration in general practicability. In net design however ease of handling must be a factor of prime importance and if the full sampling potential of all the ships available for the Indian Ocean Expedition is to be realised a net must be adopted of such a size as to be operated with ease from the smallest as well as the largest vessels.

Mesh Size

No single net can sample all the diverse forms of plant and animal life that collectively can be defined as the plankton. The most complete picture will be given by samples taken with a series of nets each constructed of different mesh size selected so as to sample different sized organisms. Even so it is likely that the finest meshes do not take the smallest organisms while the coarest meshes do not allow capture of some of the more active organisms. Sampling, even with a range of nets, is thus something of a compromise in which organisms at each end of the size range will not be effectively sampled. Replicate hauls are of course in addition, time consuming.

In a project such as of the Indian Ocean Expedition, in which ships with varying facilities will be involved, it is unlikely that any cooperative sampling programme involving more than one net will be possible. It will thus be necessary to use a single net in which the mesh size will be a compromise selected to give the best overall sample of those animals considered to be ecologically of greatest importance.

In figure 1 mesh size expressed as meshes per cm. is indicated for each of the nets, while more complete data including mesh aperture is given in table 1. From the data it will be seen that there is great variation in the mesh size used varying from 11 - 38 meshes/cm. The two smaller Juday nets, the NF70V, the Woods Hole 3/4 metre net and the Hensen net differ least in mesh size and one might thus suppose that on an average they all sample the same size range of organisms. In extreme conditions however, for example dense phytoplankton, it is likely that they sample differently and the finer meshes would presumably clog first.

There is so little comparative data on the catching powers and sampling selectivity of nets of different meshes and design that it is extremely difficult to reach a compromise from the data given here. It must be remembered however that the sampling programme in the International Indian Ocean Expedition will be largely oceanic and so for general sampling a net yielding collections of the medium sized zooplankton would appear to be desirable since of the organism taken, Euphausiids, Chaetognaths, Amphipods, and Copepods are likely to be of great ecological significance. For such a sampler mesh in the range 25-35 meshes/cm. would be necessary, and in the replies received to the questionnaires such sizes were recommended by a number of workers.

Type of haul and speed of tow

While the need for a standard net has been emphasized it is also essential that such a net be operated in a routine manner if the collections made with it are to be truly comparable. Nets may be hauled vertically or towed horizontally and obliquely and from the data summarised in table 1 it will be seen that there is no method common to all investigations; and furthermore, the speed of tow, which directly effects the volume of water filtered, varies from less than 1 knot up to 4 knots.

Each of the three methods by which a net may be fished has its own advantages and disadvantages and these must be considered in relation to the type of sampling programme envisaged and the facilities of the ships available. Horizontal or oblique tows commend themselves because they can be of a relatively long duration so yielding large catches of organisms, suitable in particular for distributional studies. Either method appears at first sight to be easier than that of making a vertical haul but if a routine method is to be adopted it is essential that at each station the net is towed at exactly the same speed, for the same time and at the same depth. This raises a number of problems since it is well known that for many ships, particularly those having diesel propulsion, the maintaining of accurate slow towing speeds of between 1½ - 2 knots presents peculiar difficulties. Variation in speed is of course of extreme importance since a slight increase or decrease can produce a large variation in the depth of the net, and it is rarely safe to assume that a net has maintained a constant fishing depth during a tow of 20-30 minutes duration.

The success of a vertical haul depends to a great extent on the ship being handled in such a way as to keep the wire vertically positioned throughout the haul. When such is the case it is ~~often~~ safe to assume that the actual maximum depth of the haul is equivalent to the amount of wire paid out measured on a meter sheave. If the wire strays from the vertical this assumption obviously cannot be made but in such cases, for depths of up to about 250 m, it is safe to make a correction based on the angle of the wire. For greater depths it is essential either that the wire be vertical or a depth recorder be used and one might go so far as to advocate the use of such an instrument in all hauls whether they be shallow or deep. The speed at which a net is hauled vertically can be controlled with great accuracy using the metre sheave of the winch or davit in conjunction with a stopwatch and in the case of the NF70V, for example, a rate of hauling of 1 metre/sec. (2 knots) can be maintained and reproduced in all hauls. Such accurate control is of course a prerequisite of any vertical closing net where the planned instant of closure is dependant upon synchronising the fall of a messenger with the rise of the net through the water. While desirable for many reasons it is unlikely, however, that closing hauls will be suitable ~~for~~ as a standard procedure since a certain amount of specialised equipment is required which would no doubt exclude the use of such a method by many ships. It seems possible however that a vertical technique of some sort would prove to be the one lending itself best to more universal duplication on all ships involved in the expedition. The requirements would be a net, a properly equipped winch and davit, a stopwatch and a flowmeter: and if the net were a relatively large one - of the Juday or NF70V type - a reasonably sized catch could be expected.

Quantitative hauls

If a standard net is used in a standard manner then the results obtained with it will be comparable and in a sense semi-quantitative since all the data can be expressed in terms of the standard haul. Should the haul be of 20 minutes duration then counts, plankton volumes etc. can be expressed per 20 minute haul, or if it be a vertical haul of say

100 metres than this could be the standard by which the data could be compared ~~relatively~~. It is desirable however that a more accurate estimation of biomass etc., be aimed at and if the survey is to be truly quantitative then the routine use of a flowmeter in the net will be a prerequisite. From table 1. it will be seen that most of the nets incorporate a flowmeter of one sort or another so that with these samplers results may be expressed in terms of the volume of water filtered. With regard to the use of flowmeters in an extensive survey it would be necessary to ensure that each meter was accurately calibrated initially and rechecked at frequent intervals during the work.

Although desirable for a true understanding of vertical quantitative distribution closing techniques, by which samples are taken from discrete depth horizons, are likely to prove too specialised for universal use as a standard method of fishing. It is encouraging however to see from the data in table 1 that so many workers are using samplers incorporating closing devices of one sort or another in their investigations.

Conclusions

The purpose of this paper has been to consider briefly some of the aspects of plankton net design and function, as revealed in the answers to the questionnaire circulated by the SCOR working group on biological methods, with particular reference to the proposed standard plankton net to be used on the International Indian Ocean Expedition. Not all of the gear has been mentioned emphasis being given to those nets most nearly comparable in their dimensions and method of use, and which as a consequence should, provide some basis for standardisation. From the various aspects of design considered it is apparent that the nets illustrated differ from each other in such a way as to make standardisation possible if somewhat difficult. Some of the differences discussed may appear trivial but remarkably little is known of the basic hydrodynamics of the flow of water through plankton nets so that a slight alteration in the design of a net may have far reaching effects on its efficiency, its validity as a sampler, and the ease with which it can be used. It is tempting to list in their possible order of importance the features requiring standardisation and such a list would include the mesh size, method of fishing, depth of tow, and the type and size of sampler. While there can be little doubt that the selection of the most suitable mesh size is of the greatest importance it must be considered in relation to the overall design and size of the net and the manner in which it is to be fished, and there would be little point in standardising one such feature - say mesh size - in the hope that it would lead to more cooperative work. The data demonstrate the great diversity of nets and other samplers and serves to indicate the many ways in which workers have evolved or adapted gear, and, shows that zooplanktologists in general are using the sampler best suited to the particular requirements of their programme. In view of this it seems likely that a recommendation for the use of a standard net (additional to the requirements of individual ~~waters~~ workers or institutions) that would be used in a simple but extensive sampling programme would meet with the greatest success.

References

CURRIE, R.I. & FOXTON, P. 1956. 'The Nansen Closing Method with Vertical Plankton Nets. J. mar biol. Ass. U.K. 35. 483-492.

KUNNE, A., 1929 Vergleich der Fangfahigkeit verschierdener Modelle von plankton-Netzen. Rapp. Cons. Explor. Mer, Vol. 59.

SYSOEV, N.A., 1956. Some hydrodynamica experiments with plankton nets. Trudy Institute Okeanolgii, 19, 324-329.

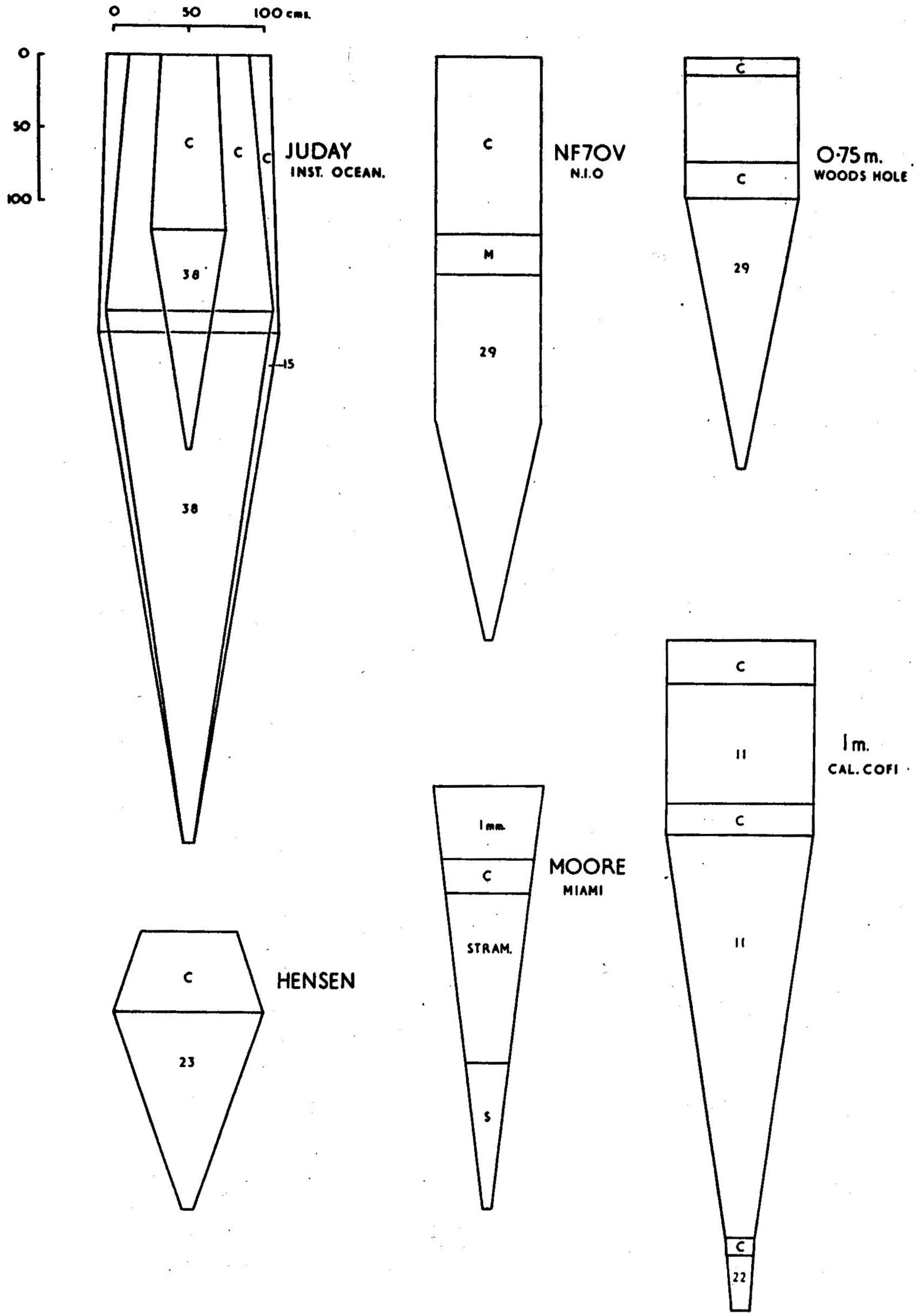
Legend to figure 1.

The outline shapes of some typical plankton nets drawn to scale
The following abbreviations have been used:- C, canvas:
M, metal: Stram, stramin:
Numbers refer to mesh size in meshes per cm.

	Australia C.S.I.R.O.	Woods Hole	Cal. COFI	University of Miami		Univ. of Washington	U.S.S.R. Inst. of Oceanology.	
Name of net.	Modif. C-B	$\frac{3}{4}$m. closing	1 metre	Discovery	17 cm	Half-metre	Juday	Juday
Diam of mouth	13 cm	0.75m	1 metre	0.75m	17 cm	0.5m	0.80m	1.13m
Quantitative ?	Yes	Yes	Yes	Semi	Semi	No	Yes	Yes
Method of tow	0 or H	0 or H	0	0 or H	0 or H	0,H or V	V	V
Speed of tow	2 - 4 kts	2 - 3kts	1kt	2 - 2kts	2 - 3kt	2 kts	-	-
Flowmeter ?	Yes	Yes	Yes	Yes	Yes(+depth)	No	-	-
Closing method	Mod. Frolander	Leavitt	No	Throttle	Throttle	No	Special	Special
Material	Nylon	Nylon	Nylon	Nylon	Nylon	Nylon	Silk	Silk
Mesh(m/cm)	25	29	11 and 21	-	graded	29	38	15
Aperture(microns)	215	233	706 and 318	351 and 202	-	215	-	-
Window bucket?	Yes	Yes	Yes	Yes	Yes	Yes	-	-

Table 1. Summarised details of some of the commoner and more closely comparable nets as revealed by the answer to the questionnaire; augmented in some cases from published datas.
The following abbreviations have been used:- C-B, Clarke-Bumpus Sampler: O, oblique haul: H, horizontal haul: V, vertical haul. A dash indicates the absence of relevant data.

Denmark	N.I.O.	Netherlands	India	Japan
Hensen	NF70V	Hensen egg net	115 cm	Marutoku
0.72m	0.72m	0.72m	1.15m	0.45 m
Yes	Yes	-	Yes	-
V	V	-	H or V	-
30 cm/sec	2 kts	-	-	-
No	Yes+(depth)	-	Yes	-
Nansen	Nansen	-	Nansen	-
Silk	N. lon	-	Silk	-
23	29	-	16 and 27	23
330	200	-	569 and 282	327
-	Yes	-	No	-



0 50 100 cms.
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C
C
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38
38
15
JUDAY
INST. OCEAN.
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29
NF7OV
N.I.O
C
C
29
0·75 m.
WOODS HOLE
C
11
C
11
C
22
1 m.
CAL. COFI
1 mm.
C
STRAM.
S
MOORE
MIAMI
C
23
HENSEN