CHAPTER 30

SYSTEMATIC MEASUREMENTS ALONG THE DUTCH COAST

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SUMMARY

Since more than a century some features of the Dutch beach have been measured systematically. Some characteristics of the coast, which could be derived from these valuable series of data, are discussed in this paper.

Since 1963 a new and largely extended program of measurements has been established, that will produce, every year, more than one million of numbers. It is hardly possible to handle such a huge quantity of data in the conventional manner; mechanical handling by means of modern computers becomes necessary. A short description is given how this is done and how it will perhaps be done in the near future.

INTRODUCTION

For the greater part, the sea has always been a mystery to us. We observe only the surface, with its eternal play of waves and wind, but below this surface a tremendous space exists in which waves and currents are acting, and of which we see nothing.

On the boundary between land and sea, on the shore, the mystery persevers. Below the surface of fore-shore and off-shore it is very difficult to obtain a clear picture of the interaction between waves, currents and bottom material. Because we cannot see it.

Above the water level, on the beach, at last we can see what is going on, but the changes in the shape of the beach are, most often, so extremely slow, that they tend to escape our attention.

However, we have to know what is going on. This certainly applies to the Dutch coast (figure 1), because this sandy coast, with its broad beaches and high dunes, is in the first place a natural defence-line against the sea. The dunes have to protect our low country against inundation during storm surges.

BEACH MEASUREMENTS

This special function of our coast, that in the same measure hardly can be found in other countries, has induced the Dutch Government, about 1850, to order the performance of regular and systematic measurements along the coast.

This was, however, a very modest start. Only the distances of the Low Water Line, the High Water Line, and the Dune Foot to fixed poles, placed every kilometer on the beach, were measured once every year, mostly during the summer season

Though these measurements have only relation to the beach itself, and though they are restricted to the movements of the above mentioned three lines, a very valuable series of data has been obtained, covering a period of more than one hundred years already. Some interesting matters could be derived from them, of which I will give here some examples.

1. The mean value of the slope of the beach between L.W. and H.W. is a point of interest, since it is supposed that the erosion of the dunes during storm surges mainly depends on this mean value. We have found that the mean value (over 100 years) of the slope of this "wet beach" decreases from South to North; Zeeland has 1:40; Holland 1:47; Texel 1:50; Terschelling 1:60 and on the Eastern Wadden islands this slope decreases until 1:80.

These slope differences are supposed to be mainly caused by differences in the coarseness of the beach sand, which is also decreasing from South to North. However, the orientation of the coast, the vicinity of an inlet, the height of the dunes a.s.o. also may have an influence on the steepness of the slope of the wet beach.

Moreover, we found that this mean value hardly depends on the movement of the coast-line as a whole; an eroding coast shows nearly the same "wet slope" as an advancing coast.

2. In contrast with the behaviour of the wet beach, the steepness of the dry beach (between H.W.-line and Dune Foot) depends largely on the movement of the coast-line. On an eroding coast the dry beach is generally steeper than the wet beach (values of 1:20 and steeper have been measured); an advancing coast is often characterized by very faint slopes of the dry beach, 1:100 and less. Therefore, two different types of beach-profiles can be distinguished, as shown in figure 2.

3. Figure 3 shows the mean values (averages over 10 years) of L.W., H.W. and D.F. in 3 ranges of the island of Ameland. It can be been, that even when the L.W.-line and the H.W.-line move landward, the dunes may grow seaward. However, when the distance between D.F. and H.W.-line becomes less than 60 meter (during a short period it may be less) the dunes cannot grow seaward any longer, but tend to retreat with the H.W.-line.

4. Figure 4 shows the passing of a "sand wave" along the North-western coast of the island of Walcheren. The movement is very slow; the top of the "wave" passes along the coast with a mean velocity of c.a. 100 m/year.

5. Figure 5 shows the behaviour of the Northern coast of the island of Terschelling (10-years averages of the H.W.-line; differences with the 1860-line, the latter plotted as a straight line). Here we do not see a passing of a sand wave. The sand, probably

originating from the inlet west of the island, stores up west of range no. 10 and forms a sort of sandy cape. This cape causes a steadely growing erosion of the ooast over the next 10 à 15 kilometers. The eastern end of the island is "wavering".

6. The northern coast of the next island, Ameland, shows the same behaviour, as may be seen from figure 6. It is remarkable, however, that from 1880 till 1900 the coast has gone back everywhere, and that the sand cape west of the range no. 8, only comes into being after 1900.

7. Figure 7 shows the behaviour of the coast of Holland, between Den Helder and Hoek van Holland, sinoe 1860. The plaoe of the Dune Foot in 1910 and 1960 compared to 1860 is plotted in each range. Between km 40 and km 95 the coast has advanced with a mean velocity of c.a. 50 m per century. South of km 95 and North of km 40 erosion has occurred, probably caused by the inlets of the southern delta and the inlet of Den Helder respectively. These coastal areas are protected by groins (the northern section only partly) and from figure 7 it may be seen, that groins are not able to stop the movement of a retreating coast entirely.

The sea-wall of Den Helder, the dike of Petten and the boulevard of Scheveningen are fixed points, where the coast cannot go back. It seems that in the neighbourhood of km 14 such a fixed point exists as well; this may perhaps be due to the existence of an old clay-layer (boulder clay?).

The break-waters of IJmuiden Harbour cause disturbances on both sides, the northern disturbanoe being the largest one.

THE NEW PROGRAM OF MEASUREMENTS

Although we have, today, to our disposal the above mentioned series of beach data, covering a period of more than one hundred years, we have to admit that our knowledge about the fundamental ooastal processes and the morphological changes along our coast is still very incomplete and shows very large gaps. This is due to the fact, that untill now we have only measured on the beach and not in the fore-shore and off-shore regions.

Still we know nothing of what occurs under water. We have hardly any idea which quantities of sand are passing along our coast and in which direction this sand moves. We do not know the quantities of sand, that go into the dunes or are withdrawn from the dunes. Seasonal variations of the beach level and changes caused by storm surges are still mainly unexplored regions.

In order to raise the level of our knowledge the Coastal Research Department of the Rijkswaterstaat has insisted on an improvement and on a large extension of the systematic measurements along our coast. We have found a willing ear to our ideas. Since 1963, January 1st, our coast is measured aocording to a new "Instruction of Coastal Measurements".

The improvements, obtained by the new "Instruction" may in short be described as follows.

1. More ranges. According to the old system one range was measured on every kilometer. Now the distances between two ranges vary between 200 and 250 meters. The place in each range is marked in the field by poles.

2. Longer ranges. Seaward, every range extends to 800 meters from the coast-line; the underwater stretch will be measured at least once yearly by echo sounding. Once in five years the echo soundings in each kilometer-range will go as far as 2500 meters off the coast. Landward every range extends till 25 meters landward of the crown of the sea-dunes.

3. Levelling. In each range a series of points on the beach and in the adjacent dune-stretch will be levelled, in order to obtain, together with the sounding data, cross sections in which the altitudes above mean sea-level are determined.

The first results of the new method can already be produced. Figure 8, an arbitrary example, shows five cross-sections of the coast of Holland, plotted by hand. Every year we will have such a profile in each range.

HANDLING OF DATA

According to the new "Instruction", 3300 ranges will be measured once a year. This means, that our field-services will produce, every year, more than one million of numbers. It is obvious that it will be hardly possible to plot such a quantity of numbers by hand, and that it will be quite impossible to put these data to a good use (a real coastal research) without the help of computers. From the beginning we were aware that dealing with such quantities of data could be effectuated only by mechanical handling.

To that end the readings of the levelling on the beach and in the dunes will be recorded upon special forms (see figure 9) by way of crossing-out the relevant numbers with a lead pencil. The recording on the special forms are done directly in the field.

The forms will be placed into an apparatus (the I.B.M. 1232 Optical Mark Page Reader) which reads the crossed-out numbers and transfers them to a punch-card. The punch-cards will be brought into our Elliot 503, producing a paper tape, in which the levelling data of <u>one</u> range are gathered.

The diagrams produced by the echo-sounding apparatus will be placed into a D-Mac-Pencil-Follower, which converts the diagrams into punch-tapes.

The levelling-tape and the echo-sounding-tape are once more placed into the Elliot, which produces a new tape in which the data of the whole cross-section (land and water) of one range are brought together. This tape forms the basis from which all further investigations will start.

From such a basis-tape we can make a diagram of the cross-section by means of the "Calcomp"-apparatus, that combines the abilities of drawing and writing. Figure 10 shows an example of such a diagram, entirely drawn and written by the machine, originally on transparent paper.

The basis-tapes form the starting point for several calculations we want to do by means of a computer. We can, for instance, easily obtain in this way the quantities of sand stored into each cross-section; we can try to find a general, average formula about the equilibrium-profile of a sandy coast; we can study, quantitatively, the behaviour of breaker ridges, the passing of sand along the coast a.s.o.

However, all this will come only to full advantage after several years, when we shal have to our disposal a series of data on every range. In a sense, today we are only laying the foundations on which the next generation of coastal engineers can base their studies.

OUTLOOK

The way in which we transpose, today, our field data into small holes in a punch-tape (i.e. the translation of numbers from the measuring-language into the computer-language) is not the most favourable one. We depend, however, on the types of apparatus and instruments which are on the market. For instance, we want to avoid punch-cards as much as possible, but today an apparatus, that transposes in one step the 1232-forms into punch-tapes is not available. Furthermore, the reading of echo-sounding-diagrams by a Pencil-Follower can perhaps be eliminated in the future; we try to develop a combined apparatus which punches directly, right on the ship, the depths <u>and</u> the distances into a paper-tape, without the detour via a sounding-diagram.

Industry in this field is developing so fast, that perhaps already within ten years we shall be able to switch over to an easier and better system of dealing with our measuring data. Today, a correct planning is difficult, and has to be very elastic, because we cannot predict the mechanical and electronical possibilities of the future.

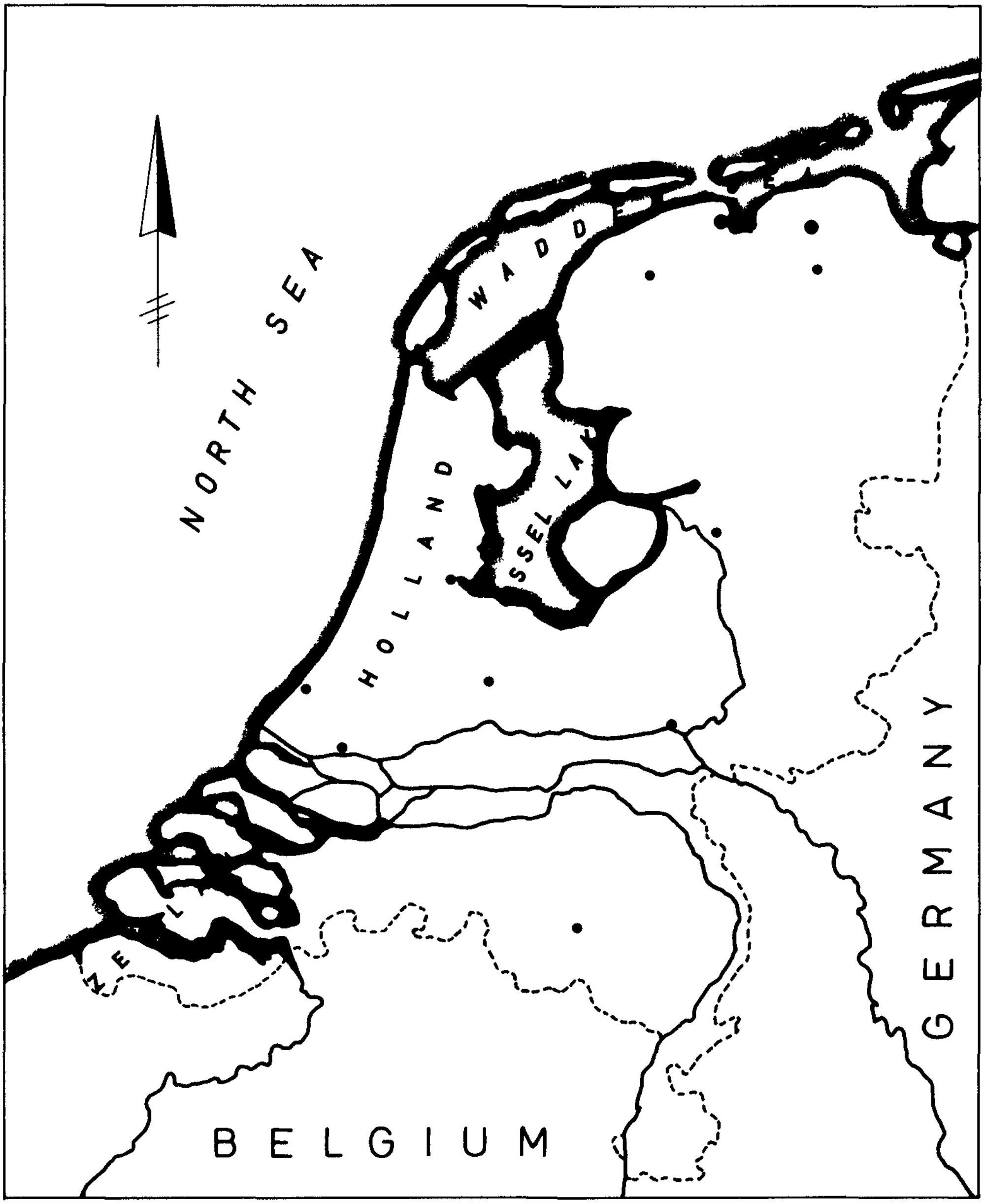

Fig. 1.

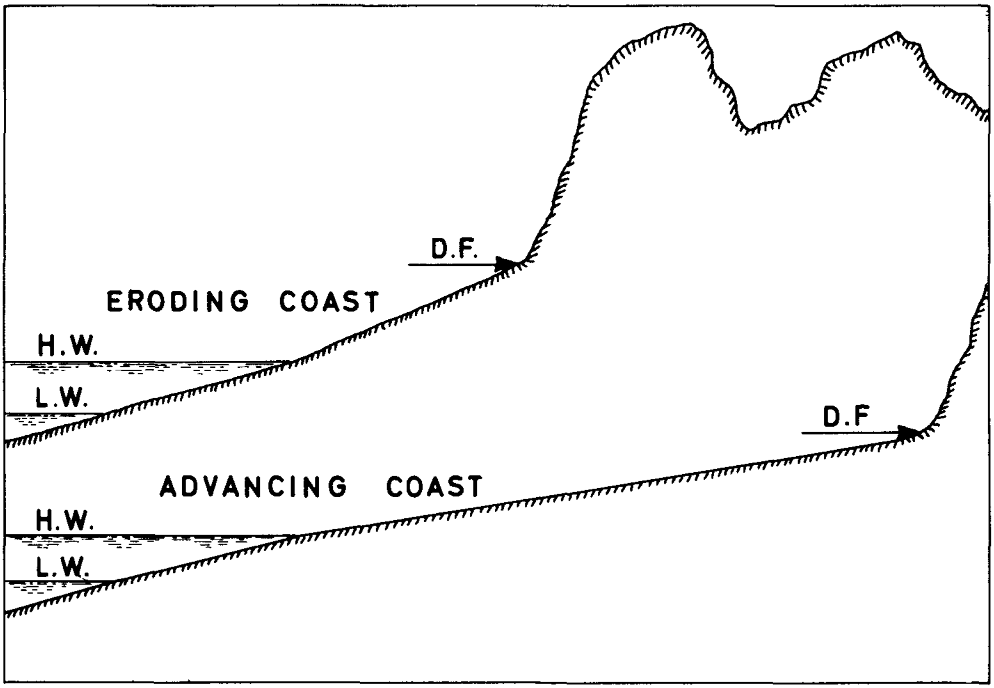
D.F.
ERODING COAST
H.W.
L.W.
D.F
ADVANCING COAST
H.W.
L.W.

Fig. 2.

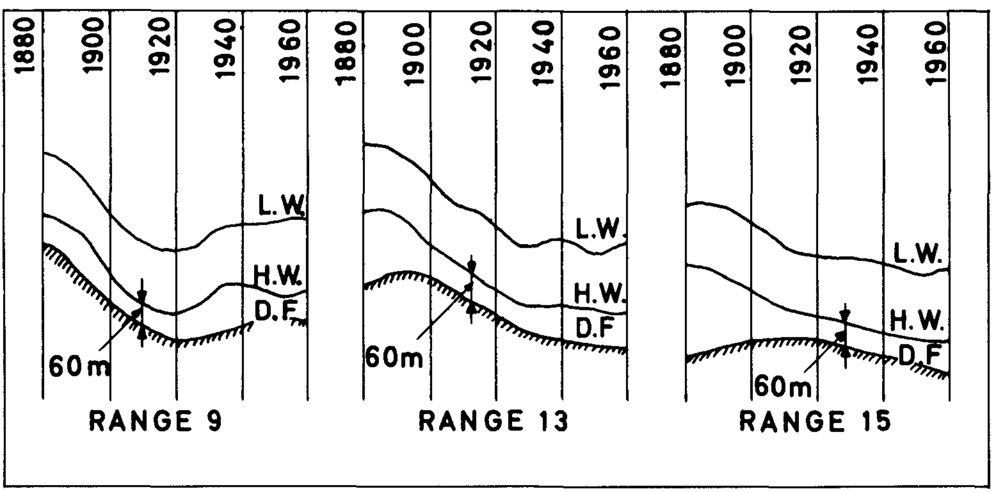
1880
1900
1920
1940
1960
L.W.
H.W.
D.F.
60m
RANGE 9
RANGE 13
RANGE 15

Fig. 3.

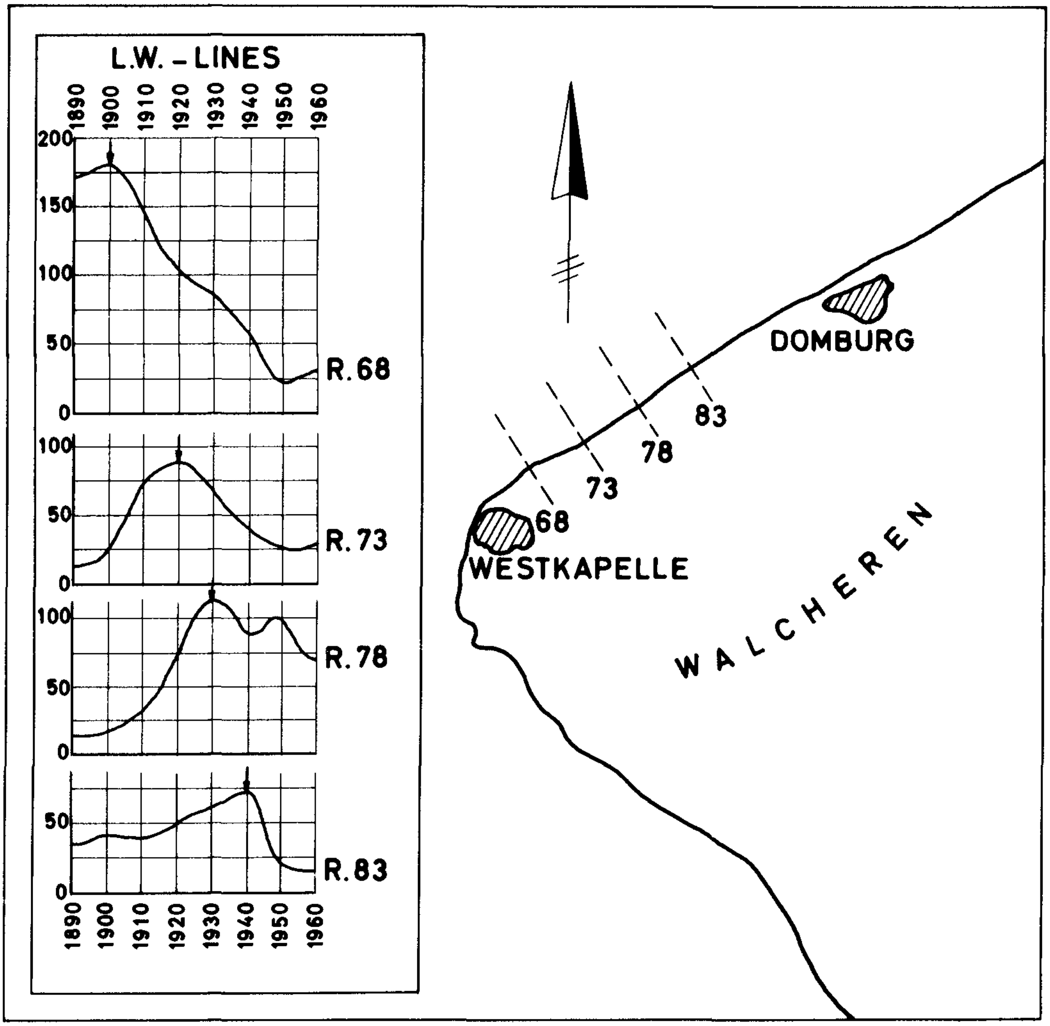
L.W. - LINES
1890
1900
1910
1920
1930
1940
1950
1960
200
150
100
50
0
R.68
100
50
0
R.73
100
50
0
R.78
50
0
R.83
DOMBURG
83
78
73
68
WESTKAPELLE
WALCHEREN

Fig. 4.

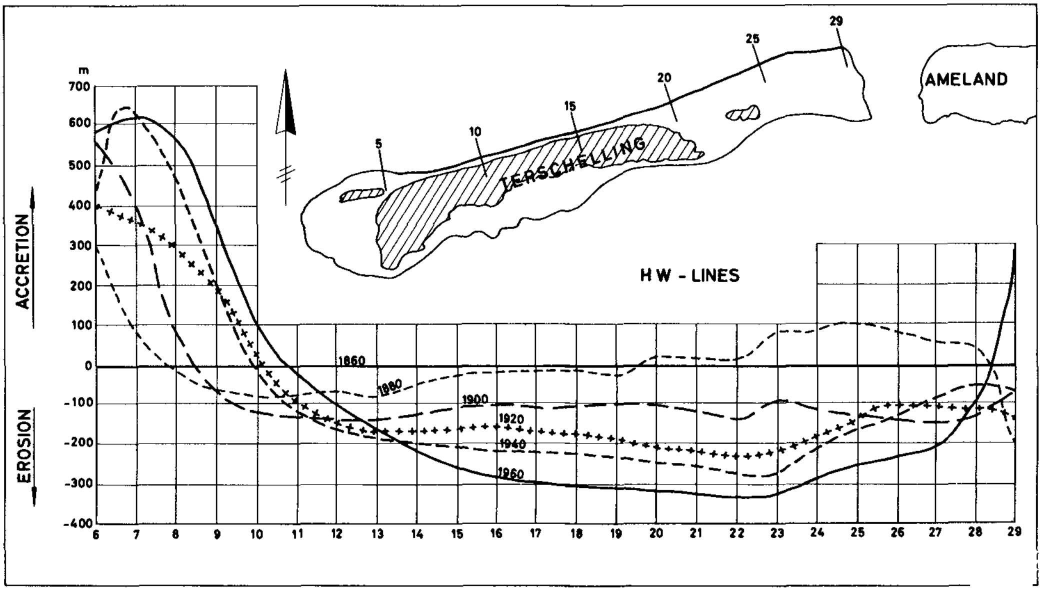
AMELAND
TERSCHELLING
HW - LINES
ACCRETION
EROSION
m
1860
1880
1900
1920
1940
1960

Fig. 5.

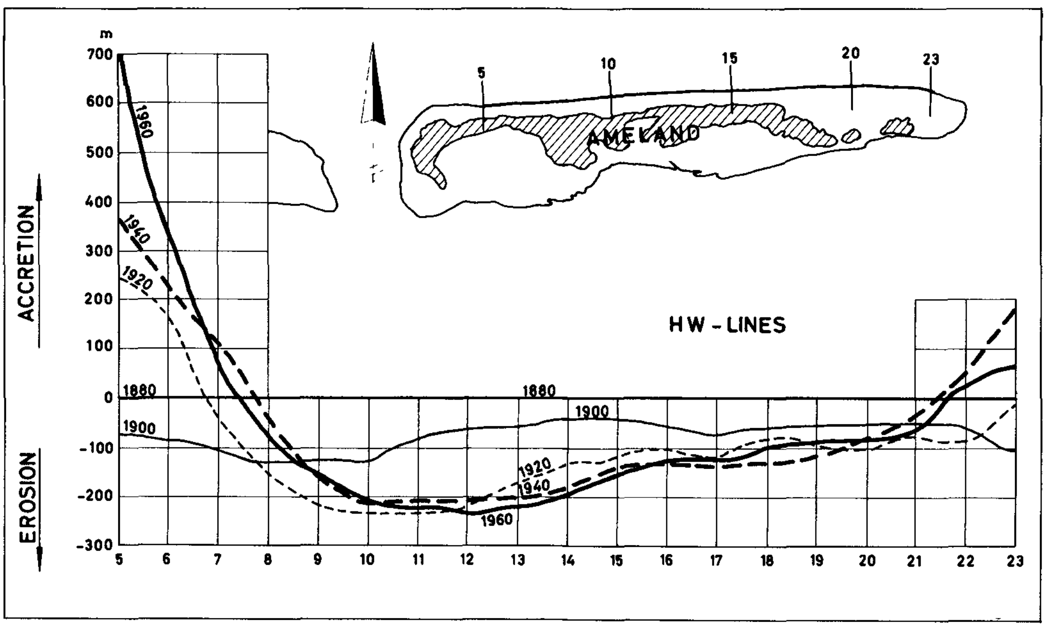
AMELAND
HW - LINES
ACCRETION
EROSION
m
1880
1900
1920
1940
1960

Fig. 6.

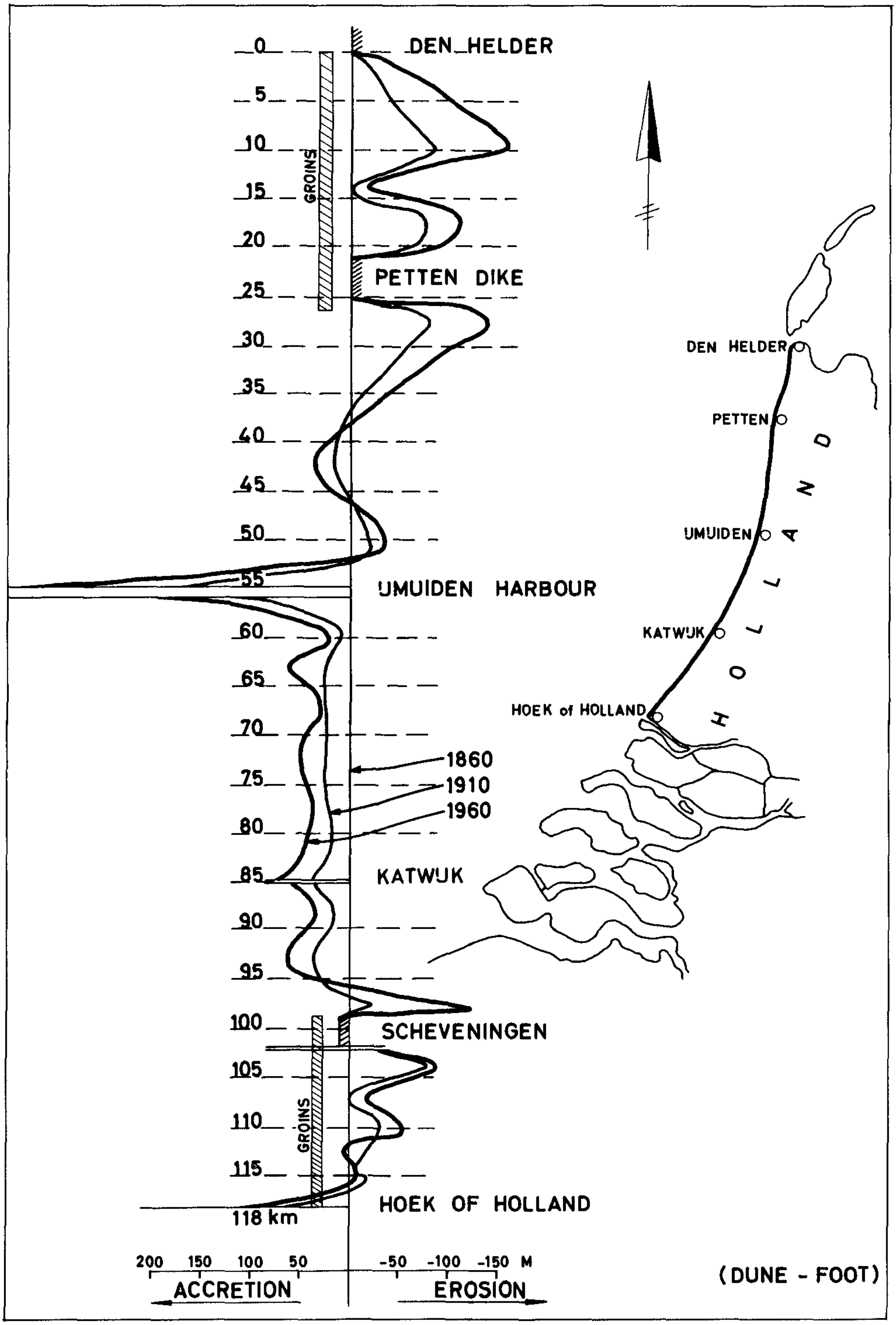
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
105
110
115
118 km
GROINS
GROINS
DEN HELDER
PETTEN DIKE
UMUIDEN HARBOUR
KATWIJK
SCHEVENINGEN
HOEK OF HOLLAND
1860
1910
1960
200 150 100 50
-50 -100 -150 M
ACCRETION
EROSION
(DUNE - FOOT)
DEN HELDER
PETTEN
IJMUIDEN
KATWIJK
HOEK of HOLLAND
HOLLAND

Fig. 7.

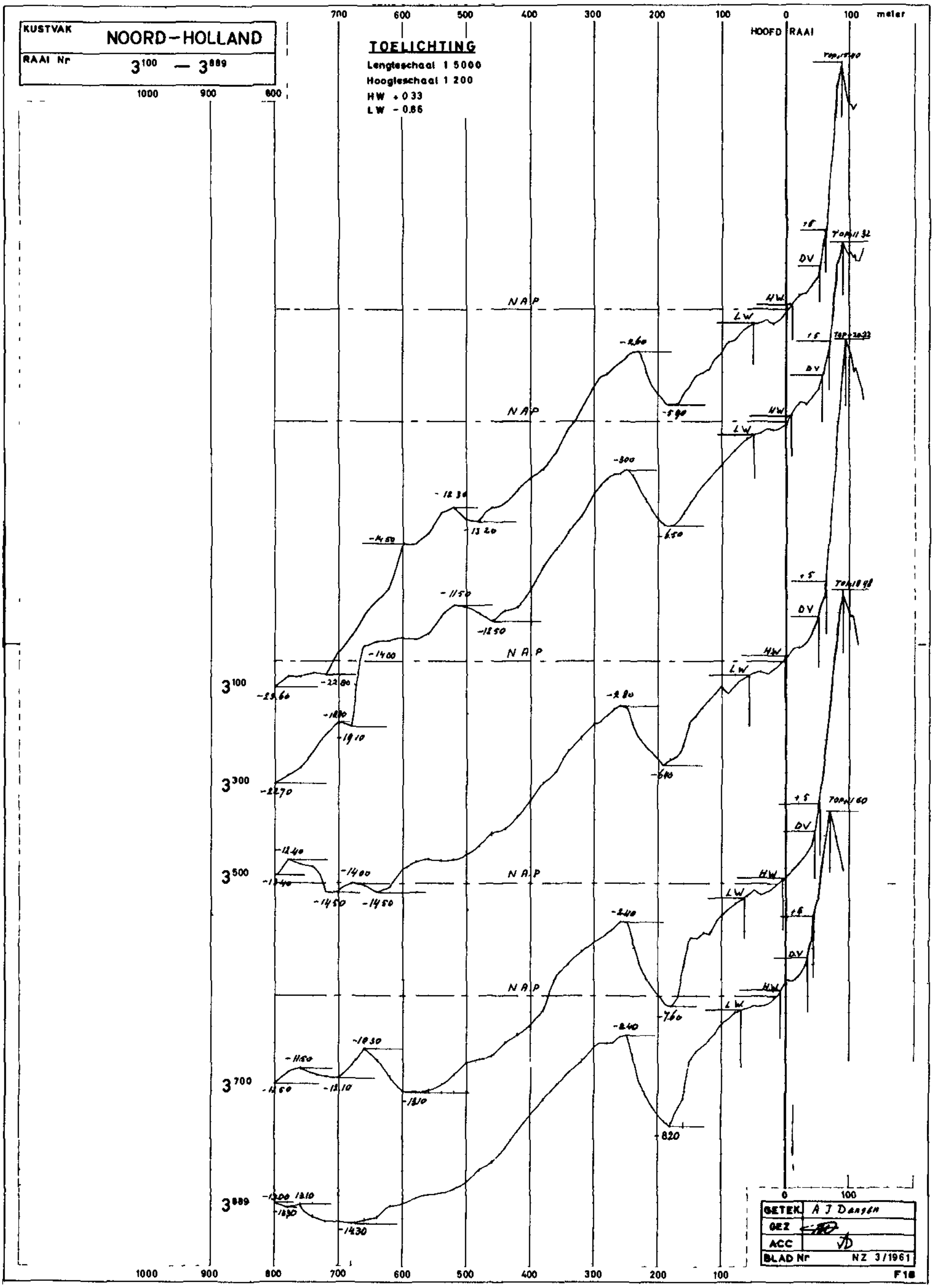
KUSTVAK
NOORD-HOLLAND
RAAI Nr
3100 — 3889
TOELICHTING
Lengteschaal 1 5000
Hoogteschaal 1 200
HW + 0 33
LW - 0.85
HOOFD RAAI
meter
NAP
HW
LW
DV
3100
3300
3500
3700
3889
GETEK A J Dansen
GEZ
ACC
BLAD Nr NZ 3/1961
F 18

Fig. 8.

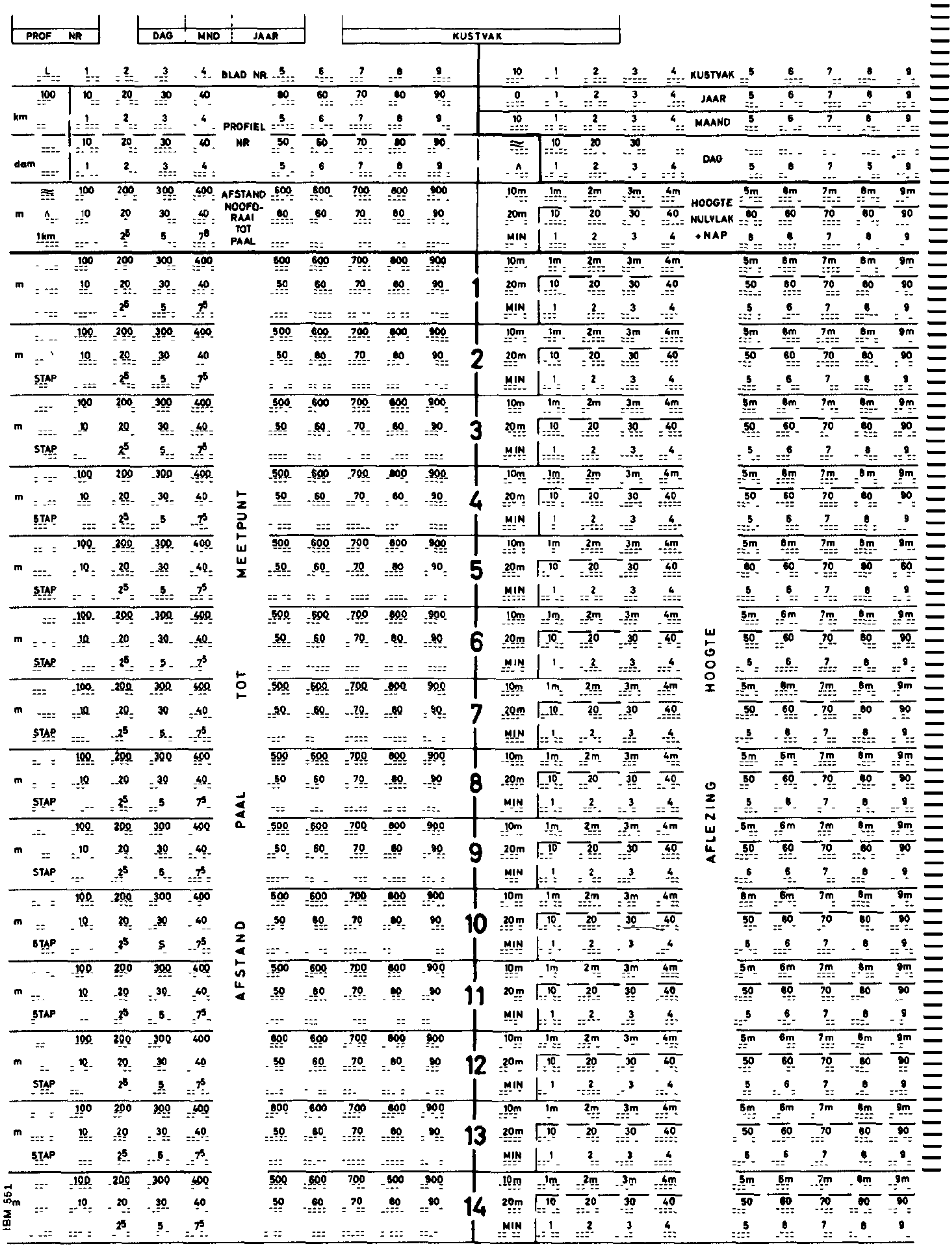
PROF NR
DAG MND JAAR
KUSTVAK
BLAD NR
KUSTVAK
JAAR
MAAND
DAG
km
dam
PROFIEL NR
AFSTAND NOORD-RAAI TOT PAAL
HOOGTE NULVLAK +NAP
MEETPUNT
AFSTAND TOT PAAL
AFLEZING HOOGTE
STAP
MIN
IBM 551

Fig. 9.

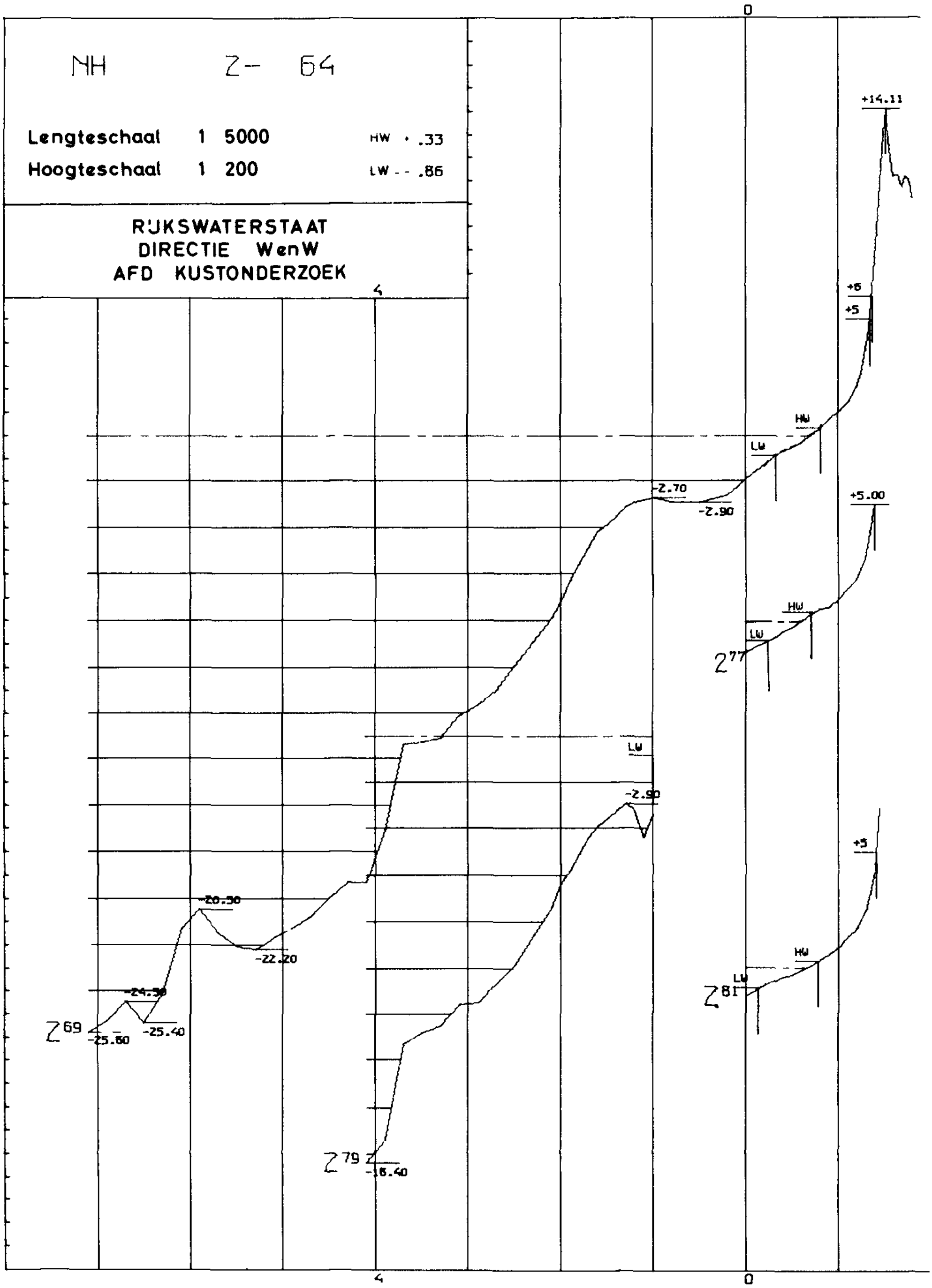
NH Z- 64
Lengteschaal 1 5000
Hoogteschaal 1 200
HW + .33
LW - - .86
RIJKSWATERSTAAT
DIRECTIE WenW
AFD KUSTONDERZOEK
0
4
+14.11
+6
+5
HW
LW
-2.70
-2.90
+5.00
HW
LW
Z 77
LW
-2.90
+5
HW
LW
Z 81
-20.30
-22.20
-24.30
-25.40
-25.60
Z 69
Z 79
-18.40
4
0

Fig. 10.