Ref

Ödsmål, Kville sn, Bohuslän

Hällristning	Rock carving
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Preliminary Investigations on the Effect of Sand Suction Work on the Bottom in the Öresund

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Hans Ackefors and Stig H. Fonselius

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Hans Ackefors and Stig H. Fonselius
Institute of Marine Research
Lysekil

One of the least expensive ways to get sand for industrial and building purposes is in many cases to suck it up from the sea bottom. Specially equipped sand sucking vessels are used for this work. Sand suckers work both in coastal waters and outside territorial waters. In the Öresund Danish sand suckers work on both the Danish and the Swedish side. Cities as Malmö, Landskrona and Hälsingborg and Swedish factories get sand from different areas in the Öresund. For sand sucking on Swedish territorial water it is necessary to get authorization from "Kungl. Kommerskollegium". In 1968 Swedish cities and factories have been authorized to take about 600 000 m^3 sand from different banks in the Öresund (figs. 1-2). The price per m^3 sand is about 0.2 Swedish Kronor.

Fishermen have complained about the effect of sand sucking on the fishing in Öresund. They have reported to the water-bailiff in Malmö that the fish occasionally is poisoned by hydrogen sulfide which is mixed up in the water during the sandsucking. Sand suckers have also destroyed or damaged nets and other gear of the fishermen.

The yield of fish in the Öresund was nearly 1 500 metric tons in 1961. The most important commercial fishes in this area are herring, cod, plaice, flounder, eel, mackerel and garfish.

The present investigation was carried out in order to find out methods for studying the effect of sand sucking on the bottom fauna and the disadvantages caused by such activity for the fishing.

Methods

The Swedish R/V "Thetis was used for the investigation carried out in June 1968. For work in very shallow water it was necessary to use the life-boat of the "Thetis". Two experienced skin divers from the Oceanographic Institute in Göteborg, fil. kand. Håkan Westerberg and fil. kand. Joel Haamer were employed for bottom investigations. Samples were taken for both hydrographical and biological studies. When working from the life boat it was convienient to let the divers take all the samples, the boat had no hydrographic equipment. The divers took the water samplers (reversing Knudsen samplers) down to the proper depth, closed them, reversed them and brought them up to the surface.

The samplers were emptied on board the "Thetis" when the work was finished. This could not be done in the life boat due to the heavy sea during the work. The divers carried out bottom investigations. Squares (0.5 x 0.5 m) were marked and all macroscopical invertebrates were counted. Biological samples were taken for classification. Simultanously a series of colour pictures were taken with an under water camera.

A Danish sand sucker working in the investigation area was visited in order to get closer informations about the working methods used. The sand sucker used a long tube with a mouth of 8 x 4 dm, divided into 8 squares. The relatively large mouth of the tube permitted rather big stones and all types of invertebrates to be sucked up from the bottom. In front of the hold, however, the bottom material passed through a metallic filter which retained gravel, stones, shells, living mussels and algue. The rough material was removed through a flute over the ships side. Biological samples were taken in the flute in order to examine algae and animals which were sucked up through the tube.

The sand sucker was constructed for work in very shallow water (1-2 m depth). The ship moved forwards about 25-50 m during the work leaving a broad furrow in the bottom. When the sand layer is thick and the depth is greater, the sand sucker anchors and sucks in one spot. A deep hole is formed in the bottom.

The working position of the sand sucker was marked with a buoy and the investigation began three hours after the sand sucker had left the place. The results of the investigation are reported below.

Biological observations

In the southern part of the Öresund the influence of sand suckers in very shallow water (4-6 m depth) was studied (Västra Haken north of Skanör). Differences in the density of the bottom fauna were observed in places influenced by sand sucking in comparison to places not influenced. In the holes and furrows made by the sand-suckers there was found an accumulation of living material e.g. algae and different kinds of mussels. In these accumulations the divers often saw eels. The furrows at Västra Haken were about 1.7 m deep and the total depth was 5.7 m. The newly made furrow had very steep walls but the walls seemed to collapse rather quickly. After a fortnight there were probably no signs left of the sand sucking, when the work was carried out in shallow water. In such places the influence of the waves often reach to the bottom and the currents may be rather strong. Of course there must be a decrease in the density of the bottom fauna, but this is not easy to observe.

In the furrow made three hours earlier there was already accumulation of algae and mussels, above all Mytilus edulis.

In the northern Öresund the depth at the bank Disken is about 12 m. Here we found big holes in the bottom larger and deeper than those we had seen earlier. The holes seemed to resist the influence of currents and waves longer at this depth. The echo sounder also showed that the bottom was broken up by many holes. The holes were 2-3 m deep with a diameter of about 14-16 m. In this place we observed the same accumulation of mussels and algae with some eels among the mass of algae. In one place the following difference was found in the bottom fauna between randomly placed squares (0.25 m^2) in the hole and on the bottom beside the hole (table 1).

Table 1.

Bottom Invertebrates Found within a Square (0.25 m^2) in a Hole made by a Sand Sucker and on a place beside the Hole.

Species	In the Hole	Beside the Hole
Harmothoe sp.	1	
Arenicola marina		1
Carcinus maenas	4	
Mytilus edulis	58	2
Cardium edule	22	7
Mya arenaria (siphons)	7	3
Mya arenaria	3	5
Macoma baltica	1	

Hydrographical observations.

At Västra Haken the greatest difficulty encountered was that the sand sucking was carried out in very shallow water and so close to land that the work could not be done on board "Thetis". The life boat had to be used and it had no hand winch and no shelter where the equipment could be stored. The weather was rather bad for work in a small boat. It was very difficult to get an exact position in the rather heavy sea because the land marks could hardly be seen. (Therefore we did not know if we were on the exact spot where the sand sucking was carried out.) When we arrived to Västra Haken no sand sucker was at work. All the water sampling had to be carried out by the divers. The water samplers were taken down by the divers with the valves open. They were closed by the divers at the proper depth. The temperatur was read in situ with a surface termometer. The divers observed shallow furrows in the bottom, but it was not possible to judge if these had been made by sand suckers. One hydrographic station was taken from the anchored life boat representing the normal conditions in the area at Västra Haken.

Table 2. Station "Västra Haken" 1. June 25 1968

Depth m	t °C	S ‰	O_2 ml/l	PO_4-P µgat/l	Si µgat/l	pH	Alk meqv/l
0	16.7	8.28	6.73	0.12	10.57	8.22	1.485
2.5	16.8	8.20	6.61	0.28	10.11	8.24	1.484
6	16.8	8.25	6.56	0.50	10.57	8.24	1.532

From the table 2 it is obvious that the water is relatively well mixed which is to be expected in a shallow area during strong wind and waves. It can, however, be seen that due to biologic activity the oxygen concentration is higher at the surface and the phosphate increases toward the bottom. There must be a strong primary production in the surface water which produces oxygen and consumes phosphate.

An agreement had earlier been made to visit a sand sucker in order to study the working technique. The 26th of June the appointment was made. In the vicinity of the sand sucker the smell of hydrogen sulfide was rather strong. Samples were taken from the water streaming over the ships side from the hold. The water was analyzed on board "Thetis". The results follow below:
O_2 3.06 ml/l, H_2S 48.0 µgat/l, PO_4-P 2.10 µgat/l, Si 35.84 µgat/l,
Alk 2.077 meqv/l.

Obviously the sand sediment contains hydrogen sulfide and the water above the sand surface contains oxygen. The two gases mix and react chemically. Because the supply of oxygen is almost unlimited in surface water, all the hydrogen sulfide will be destroyed in a very short time, probably in few hours. The phosphate rate in the sediment is very high as is to be expected in a reducing enviroment like hydrogen sulfide. Therefore we found a very high phosphate value in the sample water. The silica value was about three times the value in ordinary water from the same area. Certainly much colloidal silica had been mixed up in the water due to the sand suction.

In the afternoon samples were taken on the place where the sand sucker had worked (table 3). The place had been marked with a buoy. No traces of hydrogen sulfide could be detected. The oxygen value was 6.39 ml/l, slightly lower than at the bottom at station 1. This value could of course have a natural origin, oxygen values close to the bottom are normally lower than at the surface. Salinity and temperature were not recorded at this occasion. Analysis of reactive iron only gave traces of iron, too low to be significant.

Table 3. Station "Västra Haken" 2. June 26 1968

Depth m	O_2 ml/l	PO_4-P µgat/l	Si µgat/l	Alk meqv/l
0		0.12	7.81	1.489
2.5		0.12	8.27	1.513
4		0.21	7.35	1.497 (sea bottom)
4.7		0.54	7.81	1.500
5.7	6.39	0.68	9.13	1.702 (bottom of the hole)

As can be seen the phosphate values are quite low except in the hole itsalf. Phosphate seems to be dissolved from the sediments in small amounts. There is always some phosphate accumulated in the inner part of the sediments and when the top layer of the sediment is removed, phosphate will dissolve into the water. The silica values were only slightly higher close to the bottom of the hole.

The 27th of June the investigations was continued at "Disken". At the southern edge of "Disken" a station representing an unworked area was taken (table 4). Here the depth was around 12 m. The station was taken with "Thetis".

Table 4. Station "Södra Disken" June 27 1968.

Depth m	t °C	S ‰	O_2 ml/l	PO_4-P µgat/l	Si µgat/l	pH	Alk.meqv/l
0	16.98	14.55	6.31	0.12	5.11	8.12	
2	17.08	14.56	6.34	0.12	4.65	8.25	
4	16.85	14.64	6.35	0.10	5.11	8.22	1.699
6	16.63	14.98	6.34	0.12	5.11	8.28	
8	15.98	15.86	6.33	0.18	5.58	8.25	1.732
10	14.28	18.94	6.27	0.25	7.44	8.22	1.815
11	11.29	23.21	6.19	0.31	9.29	8.18	1.969
12	5.72	32.73	5.95	0.62	17.19	8.00	1.119

Here the extremely strong halocline between the Baltic water and the Kattegat water close to the bottom can be observed. A slight oxygen deficit may be seen in the bottom water. As a comparison a station at the Swedish side in the middle part of "Disken" was measured with a salinometer. (table 5).

Table 5. Station "Mellersta Disken" June 27 1968

Depth m	t°C	S ‰
0	16.4	14.7
5	16.4	14.75
6	16.3	14.8
7	16.2	14.7
8	16.0	14.8
9	16.0	15.1
10	16.2	14.9

Samples were also taken at this position in an old hole made by a sand sucker. (table 6).

Table 6. Old hole at "Mellersta Disken" June 27 1968

Depth m	t°C	S ‰	O_2 ml/l	PO_4-P µgat/l	Si µgat/l	pH	Alk meqv/l
14	15.94	15.72	6.21	0.44	6.97	8.16	1.726

Obviously no Kattegatt water has penetrated down into this hole. The oxygen content is here slightly lower than at the corresponding salinity and temperature on the previous station and phosphate is dissolved from the bottom. The pH is slightly lower and the silicate content a little higher, but these two factors may not be of importance.

At "Norra Disken" a station was occupied close to the sand sucking area. Unfortunately the sand sucking was carried out on Danish territorial waters. We did not have permission to work there but the territorial border was situated quite close to the place. The purpose here was to try to find out if there was any measurable oxygen deficit caused by the reaction between oxygen and hydrogen sulfide in the neighborhood of the sand sucking area. The results are given in the table 7.

Table 7. Station "Norra Disken" June 27 1968

Depth m	t°C	O_2 ml/l
0	16.35	6.44
2	16.34	6.45
4	16.39	6.40
6	16.58	6.39
8	16.44	6.41
10	16.34	6.43
12	14.56	6.17

A comparison with the station "Södra Disken" shows that the oxygen values are normal and that there always is an oxygen decrease in the deep water

close to the bottom.

Simple current observations were carried out by the divers. The current indicator was improved on board by mr. H. Westerberg. The apparatus consisted of a plastic squeezing bottle filled with fluoresceine solution. The muzzle of the bottle was connected to a 1 m long rubber tubing. The bottle was anchored in the hole by help of a nylon line and a weight so that the rubber tubing ended close to the bottom. By squeezing the bottle the diver forced fluoresceine solution into the water close to the bottom. It was now possible to observe the movement of the colored water in the hole. In very shallow water the waves caused a forth and back movement of the water. Measurements at "Västra Haken" are evident in table 8.

Table 8. Current measurements in the furrow and beside the furrow at "Västra Haken" june 26 1968.

In the furrow	Beside the furrow
Close to bottom 1 m/min	Close to bottom 2.7 m/min
4 dm above bottom 2 m/min.	4 dm above bottom 4.8 m/min
8 dm above " 2 m/min.	8 dm " " 4.0 m/min

From these preliminary observations it may be concluded that the chemical effects of sand sucking are negligible. They can only be traced in immediate neighborhood to the sand sucker during the sucking. The holes formed may be filled with heavier water and a local small stagnation may develop in the hole.

The authors' results are partly in accordance with the results from another investigation made by VALLIN (1948). He investigated an area in the "Lundåkrabukten" between Barsebäck and Landskrona. At one station very similar to our shallow station at "Västra Haken" he found that the sand sucking had very little influence upon the environment. At another station, however, stagnant water occurred in the hole made by a sand sucker. The hole was extremely deep (11.7 m) in comparison with the surrounding bottom area (4.5 - 5.0 m). The hole was filled with stagnant water of higher salinity than above the hole. Because of this fact there was no oxygen below 9 m depth and hydrogen sulphide had evolved in the hole. Bottom nets were used for fishery investigations. Very few fishes were caught at the bottom in the hole and they were all dead when the net was examined. Beside the hole, all caught fishes were alive. It is thus evident that in some areas where deep holes are made by sand suckers, the fishery may be partly damaged.

Reference

VALLIN, S., 1948: Sandsugningen och fisket i Öresund. - Svensk Fiskeritidskrift nr 6-7 pp 1-4

Plate I

1. A sand sucker working at "Disken" in the northern part of the Öresund.

2. The sand sucker "Stena" working at "Västra Haken" in the southern part of the Öresund used a long tube for sucking sand from the bottom. The mouth of the tube (8 x 4 dm) was divided into 8 squares.

3. In front of the hold the bottom material passed through a metallic filter which retained gravel, stones, shells, living mussels and algae.

Plate II

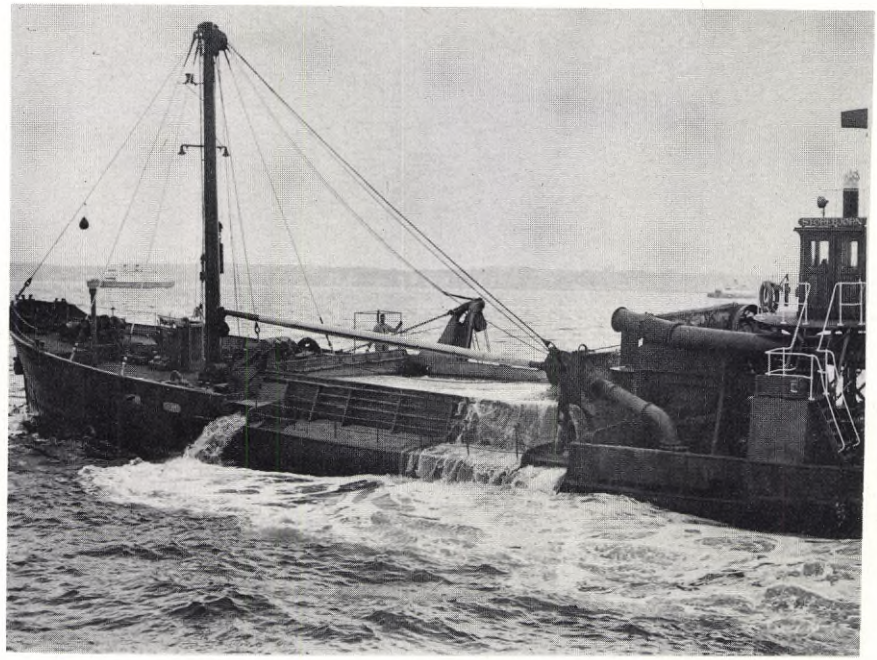
1. Sand and water passed through a metallic filter and fell down into the hold.

2. It took only two hours to fill the hold which takes about 260 m^3 sand.

3. Skin divers were employed for bottom investigations. They took both hydrographical and biological samples from bottom and near bottom. In shallow they were obliged to work from a life boat.

Plate I

1.



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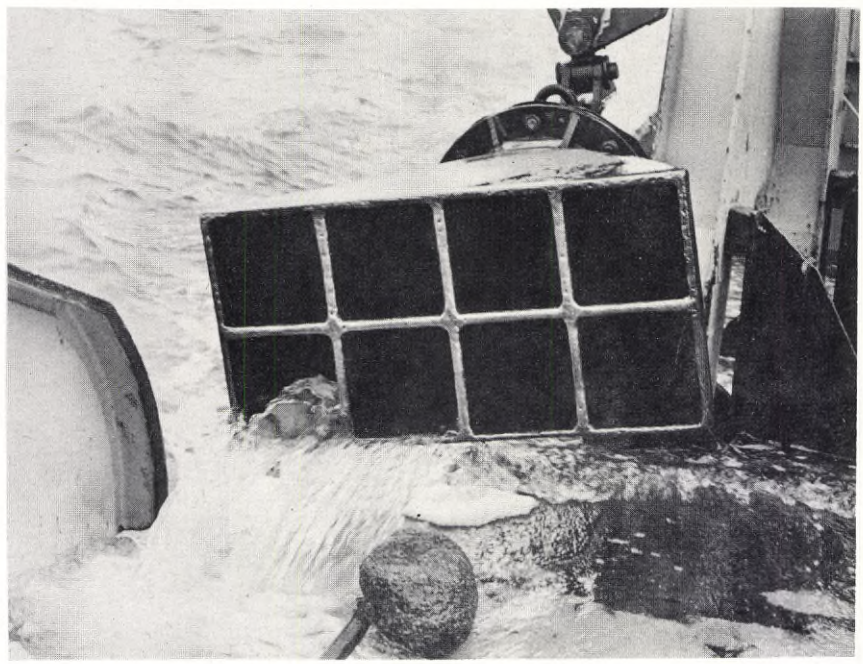

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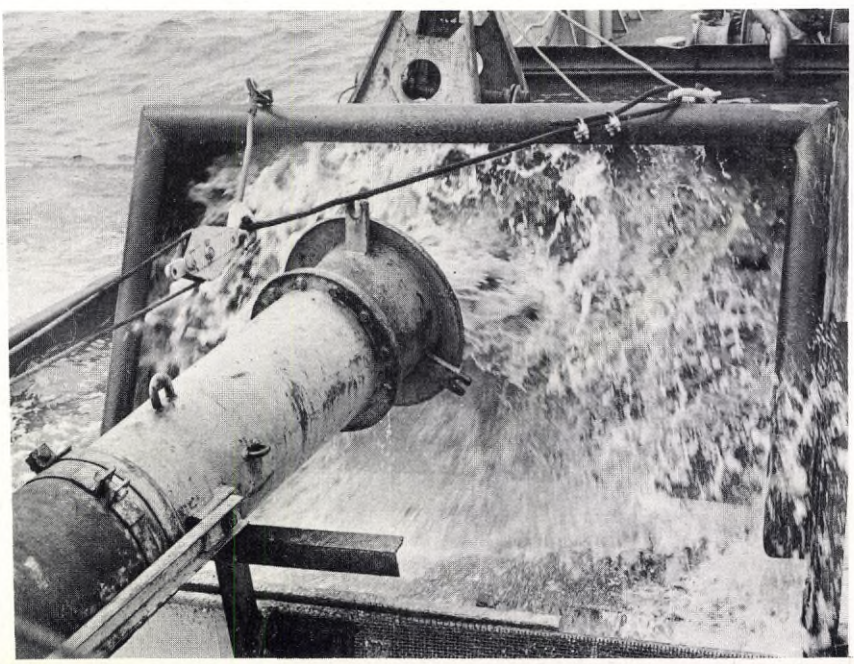
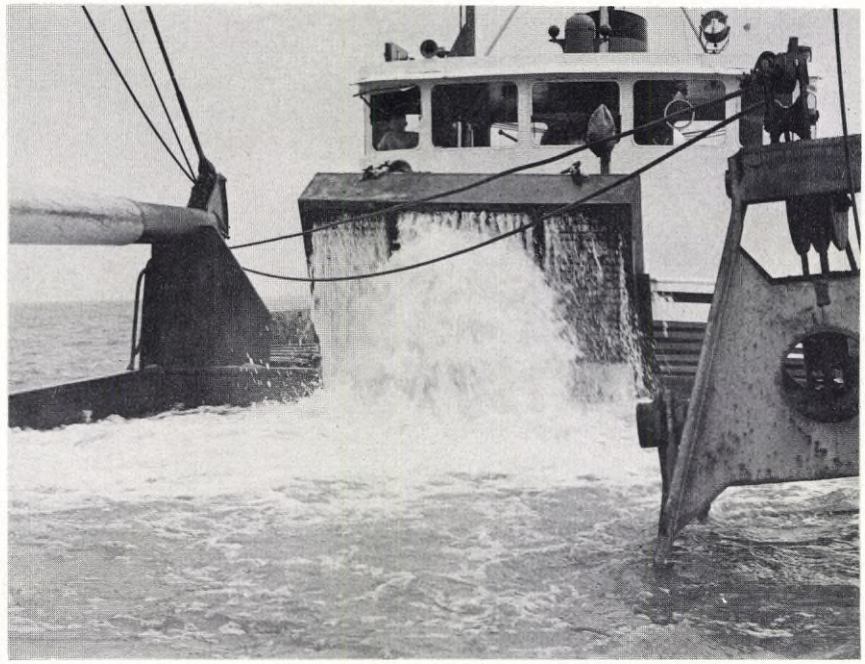


Plate II

1.



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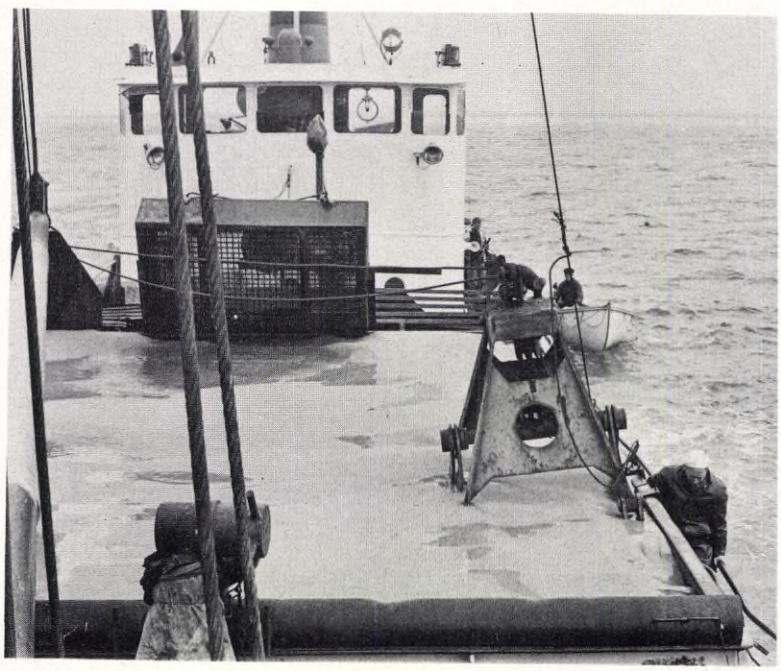

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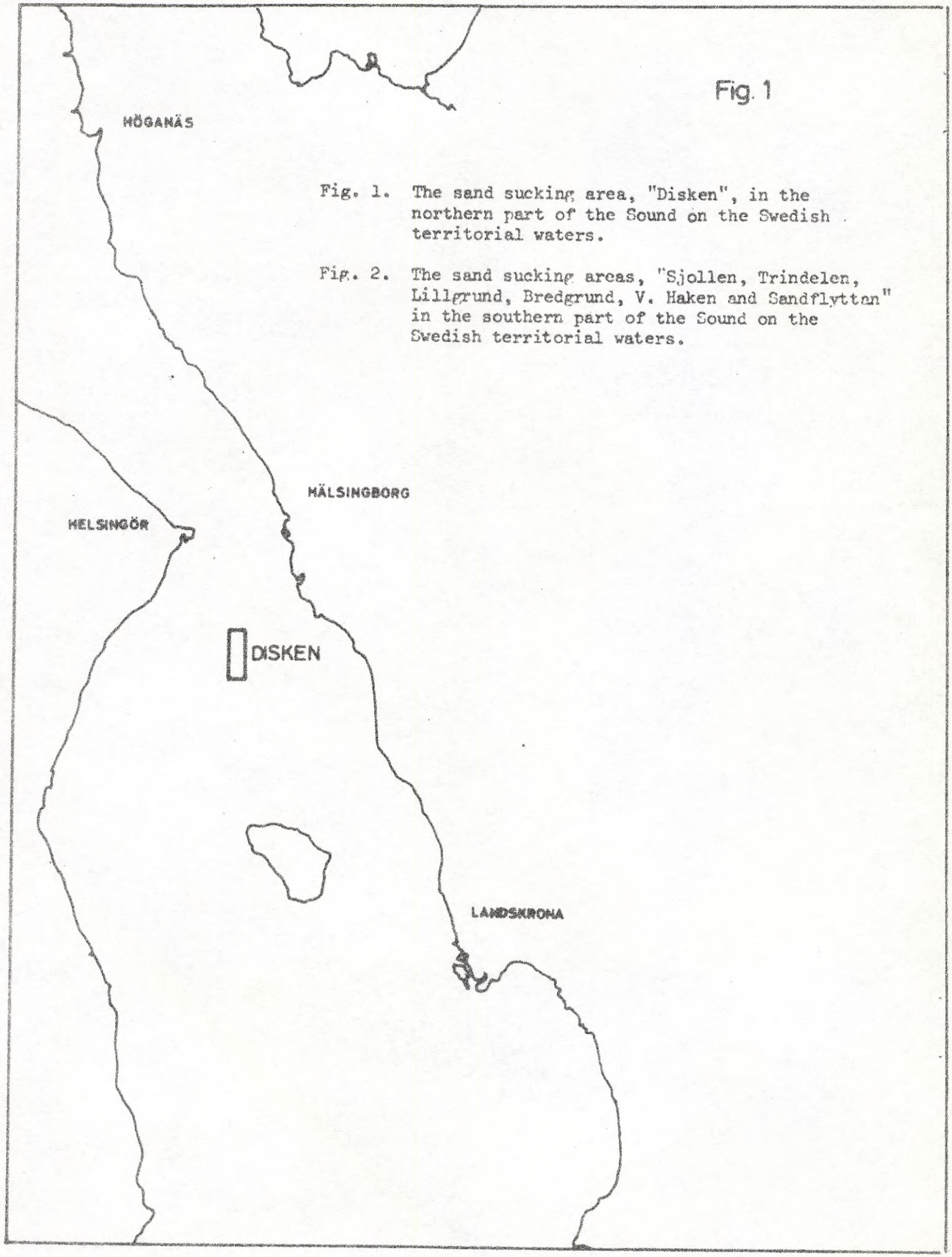

Fig. 1. The sand sucking area, "Disken", in the northern part of the Sound on the Swedish territorial waters.

Fig. 2. The sand sucking areas, "Sjollen, Trindelen, Lillgrund, Bredgrund, V. Haken and Sandflytten" in the southern part of the Sound on the Swedish territorial waters.

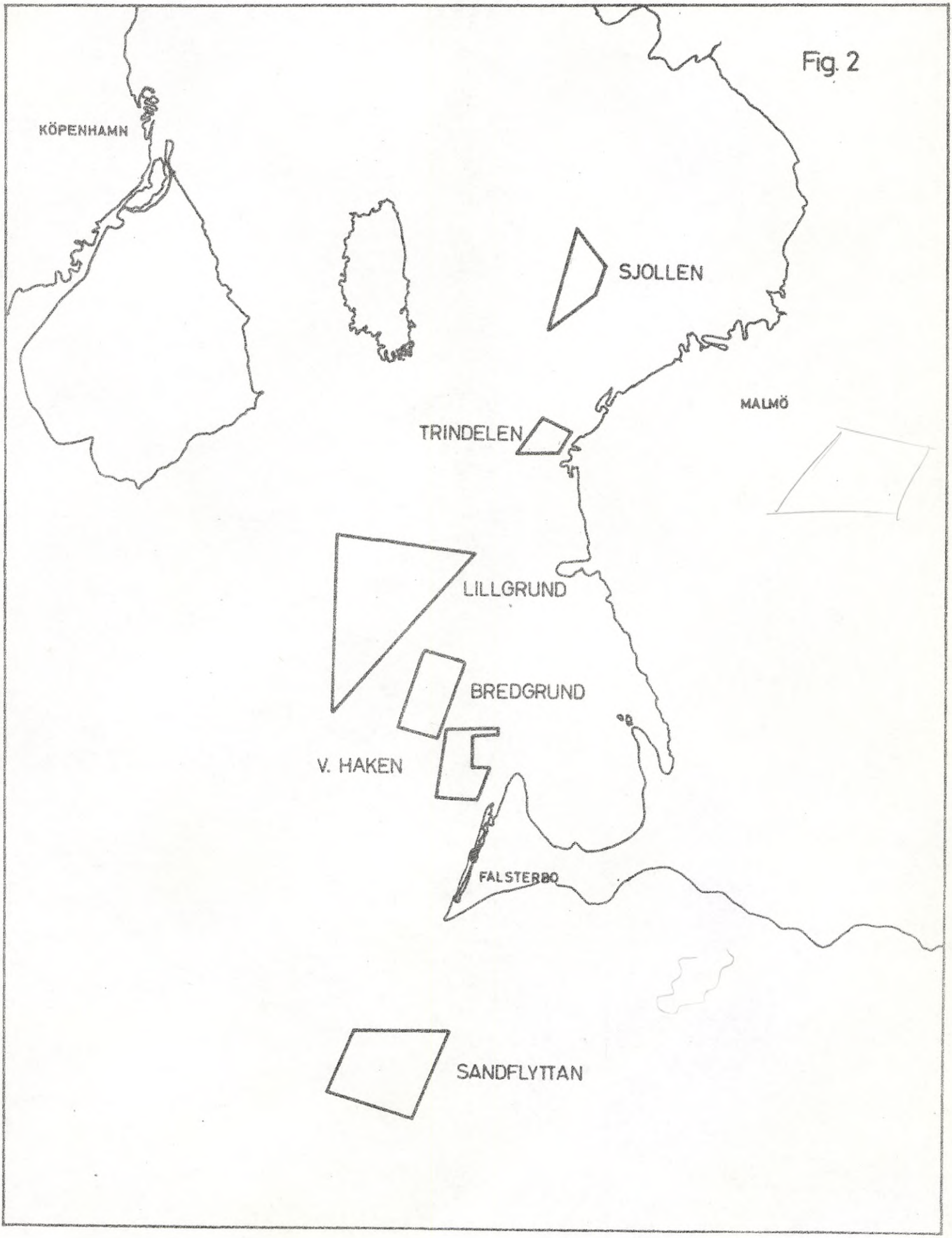
KÖPENHAMN
SJOLLEN
MALMÖ
TRINDELEN
LILLGRUND
BREDGRUND
V. HAKEN
FALSTERBO
SANDFLYTTAN

Fig. 2

Sammanfattning

I Öresund tas sand från botten av sandsugare på både danska och svenska sidan. För att suga sand på svenskt vatten är det nödvändigt med tillstånd från Kungl. Kommerskollegium. Under 1968 har svenska städer och fabriker erhållit tillstånd att ta c:a 600,000 m^3 sand från olika bankar i Öresund (se fig. 1-2). En avgift på c:a 20 öre per m^3 sand betalas av exploatörerna.

Utbytet av fisket i Öresund var omkring 1,500 ton år 1961. De viktigaste kommersiella fiskarterna var sill, torsk, skrubbskädda, rödspotta, ål, makrill och horngädda. Fiskare i området har framfört klagomål över att svavelvätet som förs upp av sandsugarna, dödar ål och att redskap förstörs vid sandsugningen. För att finna ut lämpliga metoder att studera effekten av sandsugningen gjorde Havsfiskelaboratoriet en undersökning i Öresund i juni månad 1968.

Metoder

Undersökningsfartyget Thetis, två dykare och författarna deltog i undersökningen. Biologiska och hydrografiska undersökningar utfördes. I grunda områden arbetades från en livbåt. Dykarna insamlade bottendjur från slumpvis utlagda rutor på botten, tog färgfotografier samt alla hydrografiska prover intill bottnen. Hydrografiska serier togs på vanligt sätt från Thetis, utom invid botten där dykarna alltså tog vattenproverna. Ombord på en sandsugare studerades metodiken vid sandsugningen (se fotografier). Vid detta tillfälle togs också biologiska och hydrografiska prover av det material som sandsugaren sög upp från botten.

Sandsugarens arbetssätt och påverkan på botten

Ombord på en dansk sandsugare kunde vi studera hur sandsugningen går till. Ett långt rör med en mynning av 8 x 4 dm var indelad i 8 kvadratiska rutor användes för att suga upp sanden från bottnen (bild I:2). I mycket grunda vatten sänktes röret snett framåt och fartyget förflyttade sig långsamt framåt 25-50 m under arbetets gång. Därvid bildades en bred fåra 1-2 m djup med relativt skarpa och branta kanter, som vi senare kunde konstatera med dykarnas hjälp. På djupare vatten och där sandtäcket är tjockt sög sandsugaren med lodrätt rör på en enda fläck. Då utformades ett stort hål i botten, 2-3 m djupt, och med en diameter av 14-16 m.

Sanden som sögs upp, innehöll även grova stenar, bottendjur såsom musslor och alger. Framför lastrummet filtrerades emellertid detta material bort

av ett metallfilter (bild I:3) och endast den fina sanden och de stora medföljande vattenmängderna hamnade i lastrummet (bild II:1-2). Musslor, stenar m.m. återvände till botten via en ränna.

Biologiska observationer

Det var omöjligt under en kort undersökning som denna att kunna bestämma sandsugningens effekt på bottenfaunan. Bottenfaunan (maskar, musslor m.m.) bör emellertid utarmas på ställen, där man suger. I gropar och fåror, som utbildades av sandsugaren, ansamlades djur i stora mängder, förmodligen beroende på bottenströmmarnas och vågrörelsernas inverkan (tab.1). I många av dessa hål observerades ålar som synbarligen inte var påverkade av sandsugningseffekten. I grunda områden som vid Västra Haken (norr om Skanör) försvinner dessa hål inom kort p.g.a. kraftiga strömmar och vågrörelser. I Öresund vid Disken däremot verkar hela botten uppbruten av stora hål 2-3 m djupa med en diameter av 14-16 m, som tycks motstå strömmarnas inverkan bättre. Disken ligger emellertid djupare, c:a 12 m, och påverkas tydligen inte av vågrörelser och strömmar.

Hydrografiska observationer

Lukten av svavelväte slog emot oss på håll innan vi embarkerade den danska sandsugaren och detta visade således att sandsugaren rev upp djupare lager i botten, där förruttnelseprocesser pågår. Det vatten som kom upp tillsammans med sanden, visade sig också i analyserna efteråt innehålla stora mängder svavelväte, fosfat och kisel. Fosfathalten var mycket hög och kiselhalten c:a 3 gånger högre i det vatten, som togs ombord på sandsugaren, i jämförelse med de värden, som erhölls från vattenprover i samma område tagna dagen innan sandsugningen (tab.2).

På eftermiddagen samma dag som sandsugaren hade arbetat i området kunde inga spår av svavelväte iakttagas och detta visar således att syret i vattnet reagerat med svavelvätet och att detta försvann efter en kort stund. I den fåra som sandsugaren hade gjort (tab.3), var syret obetydligt lägre än dagen innan vid botten. Fosfat- och kiselvärdena var något högre i groparna än i vattnet ovanför.

Vid Disken i norra Öresund gjordes omfattande hydrografiska studier (tab. 4-7). Södra Disken, som är ett område opåverkat av sandsugningen, användes som jämförelseområde. Vi hade för avsikt att undersöka om de svavelvätemängder, som sandsugarna river upp, ger syrebrist i bottenvattnet. Vi kunde inte konstatera någon minskning av syret i området, som påverkats av sandsugningen. Värdena var helt normala.

Enkla strömmätningar utfördes också med en apparat konstruerad av dykaren fil. kand. H. Westerberg. Ur en plastflaska pressades en fluoresceinelösning, som möjliggjorde studiet av vattenrörelserna på botten och i hålen efter sandsugningen. På grunt vatten kunde vågornas inverkan konstateras och vid större djup strömmarna registreras.

Av dessa preliminära undersökningar kan man konstatera att den kemiska effekten av sandsugningen är mycket liten. Endast i närheten av sandsugaren och under dess arbete kan förhöjda värden av vissa kemiska komponenter konstateras. De fåror och hål, som utbildas kan dock fyllas med saltare och tyngre vatten och lokalt kan därför en mindre stagnation uppträda i ett sådant hål.