Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay

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Abstract

This paper outlines a new approach to the study of power, that of the sociology of translation. Starting from three principles, those of agnosticism (impartiality between actors engaged in controversy), generalised symmetry (the commitment to explain conflicting viewpoints in the same terms) and free association (the abandonment of all a priori distinctions between the natural and the social), the paper describes a scientific and economic controversy about the causes for the decline in the population of scallops in St. Brieuc Bay and the attempts by three marine biologists to develop a conservation strategy for that population. Four 'moments' of translation are discerned in the attempts by these researchers to impose themselves and their definition of the situation on others: (a) problematisation: the researchers sought to become indispensable to other actors in the drama by defining the nature and the problems of the latter and then suggesting that these would be resolved if the actors negotiated the 'obligatory passage point' of the researchers' programme of investigation; (b) interessement: a series of processes by which the researchers sought to lock the other actors into the roles that had been proposed for them in that programme; (c) enrolment: a set of strategies in which the researchers sought to define and interrelate the various roles they had allocated to others; (d) mobilisation: a set of methods used by the researchers to ensure that supposed spokesmen for various relevant collectivities were properly able to represent those collectivities and not betrayed by the latter. In conclusion it is noted that translation is a process, never a completed accomplishment, and it may (as in the empirical case considered) fail.

Some elements of a sociology of translation

1. Introduction

The object of this paper is to present an outline of what is now called sociology of translation and to show that this analytical framework is particularly well adapted to the study of the role played by science and technology in structuring power relationships.

The starting point is to recognize that sociologists, who have attempted a detailed analysis of scientific and technological contents over the last few years, find themselves in a paradoxical situation. The explanations and interpretations proposed by these social scientists are in fact marked by a conspicuous asymmetry. When it comes to acknowledging the right of the scientists and engineers that they study to debate, sociologists' tolerance knows no limits. The sociologists act impartially and refer to the different protagonists in the same terms, even if one among them succeeds in imposing his will. The sociologists attribute the actors with neither reason, scientific method, truth, nor efficiency because these terms denote the actor's success without explaining the reasons for it.[1] This perspective has been at the basis of very lively and detailed descriptions of the shaping of science.[2]

However, the liberalism of these sociologists does not extend to allow the actors studied to discuss society and its constituents in an open manner. For once they have taken the scientific and technical aspects of the controversies into account, the sociologists faithfully restore the existing points of view to their places and, in addition, they rightly abstain from taking sides. They acknowledge the existence of a plurality of descriptions of Nature without establishing any priorities or hierarchies between these descriptions. However, and this is where the paradox is revealed, within their proposed analyses, these social scientists act as if this agnosticism towards natural science and technology were not applicable towards society as well. For them Nature is uncertain but Society is not.[3]

Is it a matter of simple privilege which sociologists grant themselves through a corporatist reflex when they remove their own knowledge from public discussion? The answer is not quite that simple. This asymmetry plays a crucial role in the explanation of science and technology. Since Nature by itself is not in a position to establish a consensus between experts, then sociologists and philosophers require something which is more constraining and less equivocal, to explain the emergence, development, and eventual closure of controversies. Some relegate this superior force to the scientific method and, consequently, to the existence

of social norms which guarantee its execution.[4] Others turn to existing social forces such as classes, organizations or professions.[5] When the society described by sociologists confronts nature (no matter which description they give), society always has the last word.[6] If the norms are removed, the sciences collapses. If the existence of social classes and their interests is denied or if the battle waged against scientists to increase their personal capital of credibility disappears, then science and technology comes to a halt, deprived of any outlet.

This frequently implicit privilege bestowed on social sciences concerning the manner in which science and technology are explained leads to three major difficulties.

The first and most apparent difficulty is a matter of style. Although scientists and engineers who are involved in the most technical of controversies are as suspicious of society as they are of nature, the sociologists' account generally bears no trace of the actors' discussions concerning social structures. The sociologist tends to censor selectively the actors when they speak of themselves, their allies, their adversaries, or social backgrounds. He allows them to express themselves freely only when they speak of Nature. The few rare texts in which this censorship is not imposed produce a very different literary effect.[7] This is due to the simple fact that the actors are not separated from a part of themselves. The impression of sociological reductionism too often given by the best writings on scientific content is evidently a product of this systematic and at times relentless censorship undertaken by sociologists in the name of sociology. Researchers have the right to debate in the most minute detail over solar neutrinos, coefficients of statistical association, and the shape of the brain, but the social analyses and interpretations which they propose and discuss at the same time are considered to be irrelevant, or worse, are used against them to criticize their scientific and technical choices.[8] Sometimes the effect can be so devastating that the reader has the impression of attending a trial of natural science presided over by a privileged scientific knowledge (sociology) which has been judged to be indisputable and above criticism.

The second difficulty is of a theoretical nature. As a number of authors have revealed, the controversies over sociological explanations are interminable. Sociologists only very rarely succeed in coming to any agreement among themselves. Just like the scientists they study, they are divided by continuing con-

troversies. Consensus, when it occurs, seems even more rare and fragile than in other fields. Should one speak of social classes and interests rather than norms and institutions? The debate is as old as sociology itself and does not spare the sociology of sciences. This is because one position is defended with as much pugnacity and success as the other.[9] Is it legitimate to speak of social classes when the observations are based on only a few individuals? How can norms or rules of the game be isolated and how can their generality be determined? These are amongst the questions that divide the social sciences and show no signs of disappearing. The issue is clear: the sociological explanation of scientific and technical controversies is as debatable as the knowledge and objects which it accounts for. The theoretical difficulty is the following: from the moment one accepts that both social and natural sciences are equally uncertain, ambiguous, and disputable, it is no longer possible to have them playing different roles in the analysis. Since society is no more obvious or less controversial than Nature, sociological explanation can find no solid foundations.[10]

The third difficulty is methodological. During their elaborations, those sociologists who have studied scientific and technical innovations have realized that both the identity and the respective importance of the actors are at issue in the development of controversies. What are the convictions of Pasteur or Pouchet concerning spontaneous generation? The positions of the protagonists are never clearly defined, even retrospectively. This is because the definition of these positions is what is at issue.[11] What actually were the interests of Renault when the EDF announced that the end of the twentieth century would inevitably see extensions in the use of electric vehicles? Who could one have turned to to know what Renault really wanted?[12] Science and technology are dramatic 'stories' in which the identity of the actors is one of the issues at hand. The observer who disregards these uncertainties risks writing a slanted story which ignores the fact that the identities of actors are problematic.

One way to avoid these difficulties would be to return to the beginning and simply deny the possibility of providing a sociological definition of science and technology. Another possibility conserves and extends the recent findings of the sociology of science and technology. In this paper, we hope to show that the analysis can be carried out using a society which is considered to be uncertain and disputable. Within the controversies studied, the intervening actors develop contradictory arguments and points of view which

lead them to propose different versions of the social and natural worlds. What would happen if symmetry were maintained throughout the analysis between the negotiations which deal with the natural and the social worlds? Would the result inevitably be total chaos? These are the questions which we will attempt to answer in this study.

To avoid the three difficulties presented above, we have decided to obey faithfully the following three methodological principles.

The first principle extends the agnosticism of the observer to include the social sciences as well. Not only is the observer impartial towards the scientific and technological arguments used by the protagonists of the controversy, but he also abstains from censoring the actors when they speak about themselves or the social environment. He refrains from judging the way in which the actors analyze the society which surrounds them. No point of view is privileged and no interpretation is censored. The observer does not fix the identity of the implicated actors if this identity is still being negotiated.

The second principle is one of generalized symmetry. It is similar to D. Bloor's principle of symmetry but is considerably extended.[13] The goal is not only to explain conflicting viewpoints and arguments in a scientific or technological controversy in the same terms. We know that the ingredients of controversies are a mixture of considerations concerning both Society and Nature. For this reason we require the observer to use a single repertoire when they are described. The vocabulary chosen for these descriptions and explanations can be left to the discretion of the observer. He can not simply repeat the analysis suggested by the actors he is studying. However, an infinite number of repertoires is possible.[14] It is up to the sociologist to choose the one that seems the best adapted to his task and then to convince his colleagues that he made the right choice. Having opted in this text for a vocabulary of translation we know that our narrative is no more, but no less valid, than any other. But given the principle of generalized symmetry, the rule which we must respect is not to change registers when we move from the technical to the social aspects of the problem studied. Our hope is that the translation repertoire, which is not that of the actors studied, will convince the reader.

The third principle concerns free association. The observer must abandon all a priori distinctions between natural and social events. He must reject the hypothesis of a definite boundary which

separates the two. These divisions are considered to be conflictual, for they are the result of analysis rather than its point of departure. Further, the observer must consider that the repertoire of categories which he uses, the entities which are mobilized, and the relationships between these are all topics for actors' discussions. Instead of imposing a pre-established grid of analysis upon these, the observer follows the actors in order to identify the manner in which these define and associate the different elements by which they build and explain their world, whether it be social or natural.[15]

An example of the application of these principles is provided in the following text. Our goal is to show that one can question society at the same time as the actors and explain how they define their respective identities, their mutual margins of manoeuvre and the range of choices which are open to them. As we hope to prove, this story should lead to a better understanding of the establishment and the evolution of power relationships because all the fluctuations which occur are preserved. In the episode which is traced here, the capacity of certain actors to get other actors – whether they be human beings, institutions or natural entities – to comply with them depends upon a complex web of interrelations in which Society and Nature are intertwined.

II Scallops and fishermen

Highly appreciated by French consumers, scallops have only been systematically exploited for the last twenty years. Over a very short period they have become a very sought-after gourmandise to the extent that during the Christmas season, although prices are spectacularly high, sales increase considerably. They are fished in France at three locations: along the coast of Normandy, in the roadstead of Brest, and in St. Brieuc Bay. There are several different species of scallops. Certain ones, as in Brest, are coralled all year round. However, at St. Brieuc the scallops lose their coral during spring and summer. These characteristics are commercially important because, according to the convictions of the fishermen, the consumers prefer coralled scallops to those which are not.

Through the 70's, the stock at Brest progressively dwindled. This was due to the combined effects of marine predators (starfish), a series of hard winters which had lowered the general temperature of the water, and the fishermen who, wanting to

satisfy the insatiable consumers, dredged the ocean floor for scallops all year round without allowing them time to reproduce. The production of St. Brieuc had also been falling off steadily during the same period, but fortunately the Bay was able to avoid the disaster. There were fewer predators and the consumers' preference for coralled scallops obliged the fishermen to stay on land for half the year. As a result of these factors, the reproduction of the stock decreased less in St. Brieuc Bay than at Brest.[16]

The object of this study is to examine the progressive development of new social relationships through the constitution of a 'scientific knowledge' that occurred during the 1970's.[17] The story starts at a conference held at Brest in 1972. Scientists and the representatives of the fishing community were assembled in order to examine the possibility of increasing the production of scallops by controlling the cultivation of these crustaceans. The discussions were grouped around the following three elements.

1) Three researchers who are members of the CNEXO[18] have discovered during a voyage to Japan that scallops are being intensively cultivated there. The technique is the following: the larvae are anchored to collectors immersed in the sea where they are sheltered from predators as they grow. When the shellfish attain a large enough size, they are 'sown' along the ocean bed where they can safely develop for two or three years before being harvested. According to the researchers' accounts of their trip, this technique made it possible to increase the level of existing stocks. All the different contributions of the conference were focused around this report.

2) There is a total lack of information concerning the mechanisms behind the development of scallops. The scientific community has never been very interested in this subject. In addition, because the intensive exploitation of scallops had begun only recently, the fishermen knew nothing about the earlier stages of scallop development. The fishermen had only seen adult scallops in their dredges.[19] At the beginning of the 1970s no direct relationship existed between larvae and fishermen. As we will see, the link was progressively established through the action of the researchers.

3) Fishing had been carried out at such intensive levels that the consequences of this exploitation were beginning to be visible in St. Brieuc Bay. Brest had practically been crossed off the map. The production at St. Brieuc had been steadily decreasing. The scallop industry of St. Brieuc had been particularly lucrative and the fishermen's representatives were beginning to worry about the

dwindling stock. The decline of the scallop population seemed inevitable and many feared that the catastrophe at Brest would also occur at St. Brieuc.

This was the chosen starting point for this paper. Ten years later, a 'scientific' knowledge was produced and certified; a social group was formed (the fishermen of St. Brieuc Bay) through the privileges that this group was able to institute and preserve; and a community of specialists was organized in order to study the scallops and promote their cultivation.[20] We will now retrace some part of this evolution and see the simultaneous production of knowledge and construction of a network of relationships in which social and natural entities mutually control who they are and what they want.

III The four moments of translation

To examine this development, we have chosen to follow an actor through his construction-deconstruction of Nature and Society. Our starting point here consists of the three researchers who have returned from their voyage to the Far East. Where they came from and why they act is of little importance at this point of the investigation. They are the primum movens of the story analyzed here. We will accompany them during their first attempt at domestication. This endeavour consists of four moments which can in reality overlap. These moments constitute the different phases of a general process called translation, during which the identity of actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited.

1 The problematization or how to become indispensable

Once they returned home, the researchers wrote a series of reports and articles in which they disclosed the impressions of their trip and the future projects they wished to launch. With their own eyes they had seen the larvae anchor themselves to collectors and grow undisturbed while sheltered from predators. Their question is simple: is this experience transposable to France and, more particularly, to the Bay of St. Brieuc? No clear answer can be given because the researchers know that the briochine species

(Pecten maximus) is different from the species raised in Japanese waters (Pecten patinopecten yessoeusis). Since no one contradicts the researchers' affirmations, we consider their statements are held to be uncontestable. Thus the aquaculture of scallops at St. Brieuc raises a problem. No answer can be given to the following crucial question: does Pecten maximus anchor itself during the first moments of its existence? Other questions which are just as important accompany the first. When does the metamorphosis of the larvae occur? At what rate do the young grow? Can enough larvae be anchored to the collectors in order to justify the project of restocking the Bay?

But in their different written documents the three researchers did not limit themselves to the simple formulation of the above questions. They determined a set of actors and defined their identities in such a way as to establish themselves an an obligatory passage point in the network of relationships they were building. This double movement, which renders them indispensable in the network, is what we call problematization.

1.1 The interdefinition of the actors

The questions formed by the three researchers and the commentaries that they provide bring three other actors directly into the story:[21] the scallops (Pecten maximus), the fishermen of St. Brieuc Bay, and the scientific colleagues.[22] The definitions of these actors, as they are presented in the scientists' report, is quite rough. However it is sufficiently precise to explain how these actors are necessarily concerned by the different questions which are formulated. These definitions as given by the three researchers themselves can be synthesized in the following manner.

a) *The fishermen of St. Brieuc:* they fish scallops to the last shellfish without worrying about the stock;[23] they make large profits; if they do not slow down their zealous efforts, they will ruin themselves. However, these fishermen are considered to be aware of their long term economic interests and, consequently, seem to be interested in the project of restocking the Bay and approve of the studies which had been launched to achieve this plan. No other hypothesis is made about their identity. The three researchers make no comment about a united social group. They define an average fisherman as a base unit of a community which consists of interchangeable elements.

b) *Scientific colleagues:* participating in conferences or cited in different publications, they know nothing about scallops in general nor about those of St. Brieuc in particular. In addition, they are unable to answer the question about the way in which these shellfish anchor themselves. They are considered to be interested in advancing the knowledge which has been proposed. This strategy consists of studying the scallops in situ rather than in experimental tanks.

c) *The scallops of St. Brieuc:* a particular species (Pecten maximus) which everyone agrees is coralled only six months of the year. They have only been seen as adults, at the moment they are dredged from the sea. The question which is asked by the three researchers supposes that they can anchor themselves and will 'accept' a shelter that will enable them to proliferate and survive.[24]

Of course, and without this the problematization would lack any support, the three researchers also reveal what they themselves are and what they want. They present themselves as 'basic' researchers who, impressed by the foreign achievement, seek to advance the available knowledge concerning a species which had not been thoroughly studied before. By undertaking this investigation, these researchers hope to render the fishermen's life easier and increase the stock of scallops of St. Brieuc Bay.

This example shows that the problematization, rather than being a reduction of the investigation to a simple formulation, touches on elements, at least partially and locally, which are parts of both the social and the natural worlds. A single question – does Pecten maximus anchor? – is enough to involve a whole series of actors by establishing their identities and the links between them.[25]

1.2 The definition of obligatory passage points (OPP)

The three researchers do not limit themselves simply to identifying a few actors. They also show that the interests of these actors lie in admitting the proposed research programme. The argument which they develop in their paper is constantly repeated: if the scallops want to survive (no matter what mechanisms explain this impulse), if their scientific colleagues hope to advance knowledge on this subject (whatever their motivations may be), if the fishermen hope to preserve their long term economic interests (whatever their reasons) then they must: 1) know the answer to

the question: how do scallops anchor?, and 2) recognize that their alliance around this question can benefit each of them.[26]

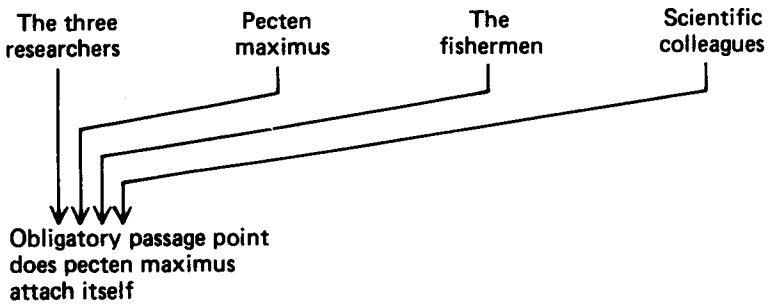

Figure 1

Figure 1 shows that the problematization possesses certain dynamic properties: it indicates the movements and detours that must be accepted as well as the alliances that must be forged. The scallops, the fishermen, and the scientific colleagues are fettered: they cannot attain what they want by themselves. Their road is blocked by a series of obstacles-problems. The future of Pecten maximus is perpetually threatened by all sorts of predators always ready to exterminate them; the fishermen, greedy for short term profits, risk their long term survival; scientific colleagues who want to develop knowledge are obliged to admit the lack of preliminary and indispensable observations of scallops in situ. As for the three researchers, their entire project turns around the question of the anchorage of Pecten maximus. For these actors the alternative is clear; either one changes direction or one recognizes the need to study and obtain results about the way in which larvae anchor themselves.[27]

As Figure 2 shows, the problematization describes a system of alliances, or associations,[28] between entities, thereby defining the identity and what they 'want'. In this case, a Holy Alliance must be formed in order to induce the scallops of St. Brieuc Bay to multiply.

2 The devices of 'interessement' or how the allies are locked into place

We have emphasized the hypothetical aspect of the problematiza-

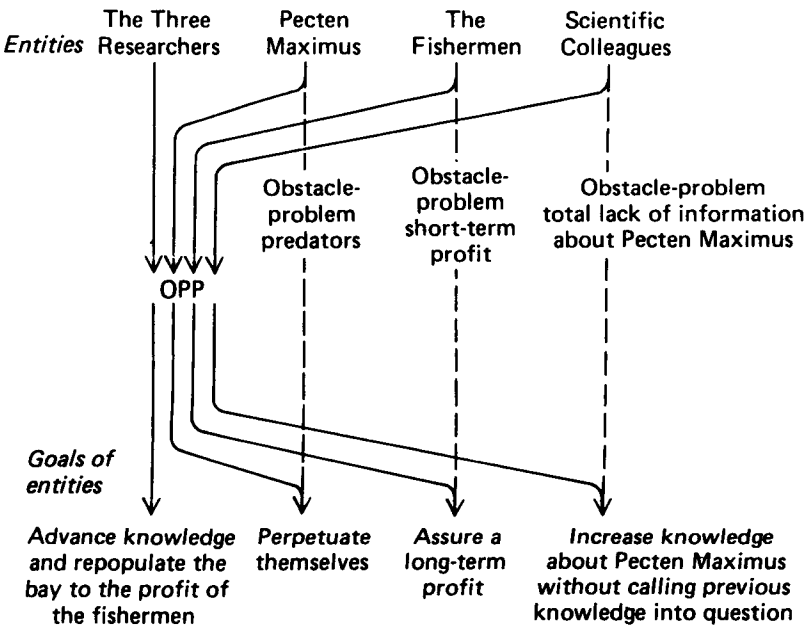

Figure 2

tion. On paper, or more exactly, in the reports and articles presented by the three researchers, the identified groups have a real existence. But reality is a process. Like a chemical body it passes through successive states.[29] At this point in our story, the entities identified and the relationships envisaged have not yet been tested. The scene is set for a series of trials of strength whose outcome will determine the solidity of our researchers problematization.

Each entity enlisted by the problematization can submit to being integrated into the initial plan, or inversely, refuse the transaction by defining its identity, its goals, projects, orientations, motivations, or interests in another manner. In fact the situation is never so clear cut. As the phase of problematization has shown, it would be absurd for the observer to describe entities as formulating their identity and goals in a totally independent manner. They are formed and are adjusted only during action.[30]

Interessement is the group of actions by which an entity (here the three researchers) attempts to impose and stabilize the identity

of the other actors it defines through its problematization. Different devices are used to implement these actions.

Why talk of interessement? The etymology of this word justifies its choice. To be interested is to be in between (inter-esse), to be interposed. But between what? Let us return to the three researchers. During their problematization they join forces with the scallops, the fishermen, and their colleagues in order to attain a certain goal. In so doing they carefully define the identity, the goals or the inclinations of their allies. But these allies are tentatively implicated in the problematizations of other actors. Their identities are consequently defined in other competitive ways. It is in this sense that one should understand interessement. To interest other actors is to build devices which can be placed between them and all other entities who want to define their identities otherwise. A interests B by cutting or weakening all the links between B and the invisible (or at times quite visible) group of other entities C, D, E, etc. who may want to link themselves to B.[31]

The properties and identity of B (whether it is a matter of scallops, scientific colleagues, or fishermen) are consolidated and/or redefined during the process of interessement. B is a 'result' of the association which links it to A. This link disassociates B from all the C, D, and E's (if they exist) that attempt to give it another definition. We call this elementary relationship which begins to shape and consolidate the social link the triangle of interessement.[32]

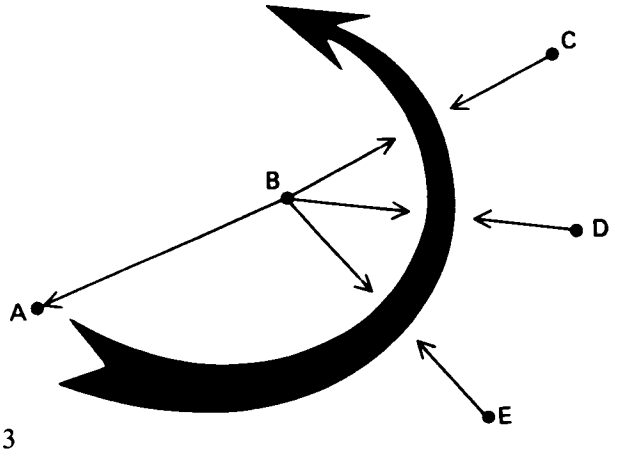

Figure 3

The range of possible strategies and mechanisms that are adopted to bring about these interruptions is unlimited. As Feyerabend says about the scientific method: anything goes. It may be pure and simple force if the links between B, C and D are firmly established. It may be seduction or a simple solicitation if B is already close to the problematization of A. Except in extremely rare cases when the shaping of B coincides perfectly with the proposed problematization, the identity and 'geometry' of the interested entities are modified all along the process of interessement.[33] We can illustrate these points by the story of the domestication of scallops.

The domestication of scallops strikingly illustrates the general interessement mechanisms. The three researchers are inspired by a technique that had been invented by the Japanese. Towlines made up of collectors are immersed in the sea. Each collector carries a fine netted bag containing a support for the anchorage of the larvae. These bags make it possible to assure the free flow of water and larvae while preventing the young scallops from escaping. The device also prevents predators from attacking the larvae. In this way the larvae are protected during the period when they have no defence: that is, when they have no shell.[34] The collectors are mounted in a series on the line. The ends of the two lines are attached to floats that are kept in place by an anchorage system.

The towline and its collectors constitute an archetype of the interessement device. The larvae are 'extracted' from their context. They are protected from predators (starfish) which want to attack and exterminate them, from currents that carry them away where they perish, and from the fisherman's dredge which damages them. They are (physically) disassociated from all the actors who threaten them.

In addition, these interessement devices extend and materialize the hypothesis made by the researchers concerning the scallops and the larvae: (1) the defenceless larvae are constantly threatened by predators, (2) the larvae can anchor, (3) the Japanese experience can be transposed to France because St. Brieuc's scallops are not fundamentally different from their Japanese cousins. The collectors would lose all effectiveness if the larvae 'refused' to anchor, to grow, to metamorphose, and to proliferate in (relative) captivity. The interessement, if successful, confirms (more or less completely) the validity of the problematiz-

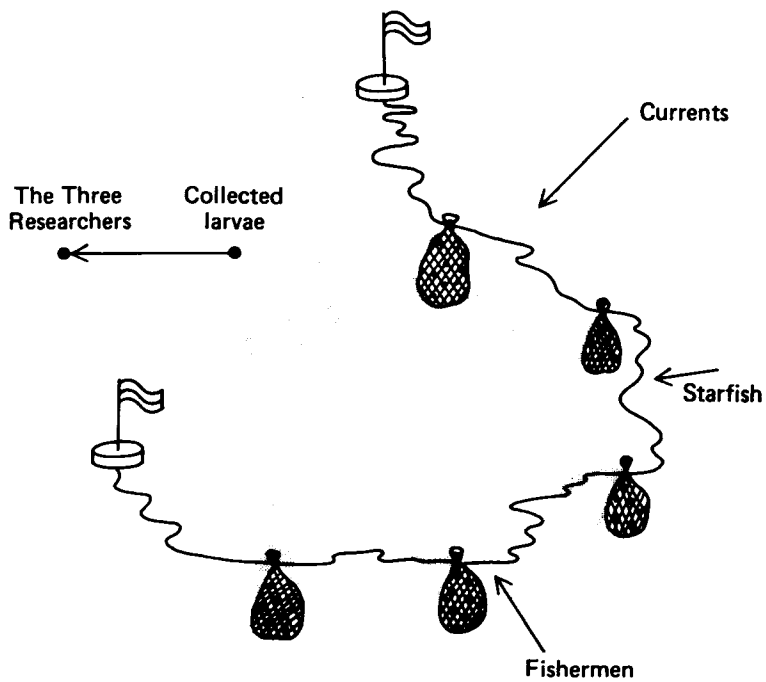

Figure 4

ation and the alliance it implies. In this particular case study, the problematization is eventually refuted.

Although the collectors are necessary for the interessement of the scallops and their larvae, this type of 'machination' proves to be superfluous for the interessement of the fishermen and the scientific colleagues. In addition, the three researchers do not intend to convince the first group as a whole. It is rather the representatives of professional organizations who are the targets of the researchers' solicitation. The three researchers multiply their meetings and debates in order to explain to the fishermen the reasons behind the extinction of the scallops. The researchers draw up and comment upon curves which 'indisputably' show the incredible decline of the stock of scallops in St. Brieuc Bay. They also emphatically present the 'spectacular' results of the Japanese. The scientific colleagues are solicited during conferences and through publications. The argumentation is always the same: an exhaustive review of the literature shows that nothing is known about scallops. This lack of knowledge is regrettable because the

survival of a species which has increasing economic importance is at stake (in France at least).[35]

For the case of the scallops (like the fishermen and the scientific colleagues) the interessement is founded on a certain interpretation of what the yet to be enrolled actors are and want as well as what entities these actors are associated with. The devices of interessement create a favourable balance of power: for the first group, these devices are the towlines immersed in St. Brieuc Bay; and for the second group, they are texts and conversations which lure the concerned actors to follow the three researchers' project. For all the groups involved, the interessement helps corner the entities to be enrolled. In addition, it attempts to interrupt all potential competing associations and to construct a system of alliances. Social structures comprising both social and natural entities are shaped and consolidated.

3 How to define and coordinate the roles: enrolment

No matter how constraining the trapping device, no matter how convincing the argument, success is never assured. In other words, the device of interessement does not necessarily lead to alliances, that is, to actual enrolment. The issue here is to transform a question into a series of statements which are more certain: Pecten maximus does anchor; the fishermen want to restock the Bay.

Why speak of enrolment? In using this term, we are not resorting to a functionalist or culturalist sociology which defines society as an entity made up of roles and holders of roles.[36] Enrolment does not imply, nor does it exclude, pre-established roles. It designates the device by which a set of interrelated roles is defined and attributed to actors who accept them. Interessement achieves enrolment if it is successful. To describe enrolment is thus to describe the group of multilateral negotiations, trials of strength and tricks that accompany the interessements and enable them to succeed.

If the scallops are to be enrolled, they must first be willing to anchor themselves to the collectors. But this anchorage is not easy to achieve. In fact the three researchers will have to lead their longest and most difficult negotiations with the scallops. Like in a fairy tale, there are many enemy forces which attempt to thwart the researchers' project and divert the larvae before they are captured. First the currents: 'Of the six towlines that were placed,

four functioned correctly before different variables intervened. It clearly appears that the larvae anchor themselves better in the innermost parts of the Bay where the tidal currents are the weakest.'[37]

To negotiate with the scallops is to first negotiate with the currents because the turbulences caused by the tide are an obstacle to the anchorage. But the researchers must deal with other elements besides the currents. All sorts of parasites trouble the experiment and present obstacles to the capture of the larvae.

> A large part of the variation is due to the way in which parasites are attracted. We have had many visitors who provoked accidents, displaced lines, entangled collectors. This immediately caused negative results. It seems that the scallops are extremely sensitive to all manipulations (displaced lines, collectors which rub against each other, etc.) and react by detaching themselves from their supports.[38]

The list goes on. A veritable battle is being fought. Currents and visitors are only some of the forces which are opposed to the alliances which the researchers wish to forge with the scallops.[39] In the triangle A-B-C which we spoke of earlier, C, the party to be excluded (whether it is called currents or starfish) does not surrender so easily. C (the starfish) has the possibility of interrupting the relationships between A (the researchers) and B (the larvae). C does this by also interesting B (the larvae) which are coveted by all.

The census done by the researcher also shows that the anchorages are more numerous 'between 5 meters above the sea floor and the sea floor itself. This is perhaps due to the depth as well as to the specific behaviour of the scallops when they anchor: the larvae lets itself sink and anchors itself to the first obstacle that stops its descent.'[40]

The towline, an interessement device, reveals the levels of anchorage to the observer. The hypotheses and the interpretations of the researchers are nothing but a programme of negotiations: larvae, should we search for you at the bottom of the Bay or should we wait for you on your way down in order to trap you as you sink?

This is not all. The researchers are ready to make any kind of concession in order to lure the larvae into their trap. What sort of substances do the larvae prefer to anchor themselves on? Another series of transactions is necessary to answer the question.

'It was noted that the development of the scallops was slower with collectors made of straw, broom, or vegetable horsehair. These types of supports are too compressed and prevent water from circulating correctly through the collector.'[41]

Thus a modus vivendi is progressively arranged. If all these conditions are united then the larvae will anchor themselves in a significant manner. But what does the adjective 'significant' signify? To answer this question, we must introduce, as in the tripartite Vietnam conferences held in Paris, the second actor with whom the three researchers must negotiate: scientific colleagues.

In the beginning a general consensus existed: the idea that scallops anchor was not discussed.[42] However, the first results were not accepted without preliminary negotiations. The proposition: 'Pecten maximus anchors itself in its larval state' is an affirmation which the experiments performed at St. Brieuc eventually called into question. No anchorages were observed on certain collectors and the number of larvae which anchored on the collectors never attained the Japanese levels. At what number can it be confirmed and accepted that scallops, in general, do anchor themselves? The three researchers are prepared for this objection because in their first communication they confirm that the observed anchorages did not occur accidentally: it is here that we see the importance of the negotiations which were carried out with the scallops in order to increase the interessement and of the acts of enticement which were used to retain the larvae (horsehair rather than nylon, etc.). With scientific colleagues, the transactions were simple: the discussion of the results shows that they were prepared to believe in the principle of anchorage and that they judged the experiment to be convincing. The only condition that the colleagues posed is that the existence of previous work be recognized, work that had predicted, albeit imperfectly, the scallop's capacity to anchor.[43] It is at this price that the number of anchorages claimed by the researchers will be judged as sufficient. Our three researchers accept after ironically noting that all bonafide discoveries miraculously unveil precursors who had been previously ignored.[44]

Transactions with the fishermen, or rather, with their representatives, are non-existent. They watch like amused spectators and wait for the final verdict. They are prepared simply to accept the conclusions drawn by the specialists. Their consent is obtained (in advance) without any discussion.

Therefore for the most part, the negotiation is carried out

between three parties since the fourth partner was enrolled without any resistance. This example illustrates the different possible ways in which the actors are enrolled: physical violence (against the predators), seduction, transaction, and consent without discussion. This example mainly shows that the definition and distribution of roles (the scallops which anchor themselves, the fishermen who are persuaded that the collectors could help restock the Bay, the colleagues who believe in the anchorage) are a result of multilateral negotiations during which the identity of the actors is determined and tested.

4 The mobilisation of allies: are the spokesmen representative?

Who speaks in the name of whom? Who represents whom? These crucial questions must be answered if the project led by the researchers is to succeed. This is because, as with the description of interessement and enrolment, only a few rare individuals are involved, whether these be scallops, fishermen or scientific colleagues.

Does Pecten maximus really anchor itself? Yes, according to the colleagues, the anchorages which were observed are not accidental. Yet, though everyone believes that they are not accidental they acknowledge that they are limited in number. A few larvae are considered to be the official representatives of an anonymous mass of scallops which silently and elusively lurk on the ocean floor. The three researchers negotiate the interessement of the scallops through a handful of larvae which represent all the uncountable others that evade captivity.

The masses at no time contradict the scallops which anchor themselves. That which is true for a few is true for the whole of the population. When the CBI negotiates with union delegates they consider the latter to be representatives of all the workers. This small number of individuals speaks in the name of the others. In one case, the epistemologists speak of induction, in another, political scientists use the notion of spokesman. The question however is the same. Will the masses (employers, workers, scallops) follow their representatives?[45]

Representation is also an issue in the researchers' transactions with the colleagues and fishermen. Properly speaking, it is not the scientific community which is convinced but a few colleagues who read the publications and attend the conference. It is not the

fishermen but their official representatives who give the green light to the experiments and support the project of restocking the Bay. In both cases, a few individuals have been interested in the name of the masses they represent (or claim to represent).

The three researchers have formed a relationship with only a few representatives – whether they be larvae on a collector, professional delegates or scientific colleagues participating at a colloquium. However it may seem that the situations are not comparable. The delegates and colleagues speak for themselves while the larvae are silent. On the one hand, they are real spokesmen but on the other, the anchored larvae are simply representatives. However this difference disappears on closer analysis.

Let us return to the scallops. The larvae which anchored themselves on the collector are 'equal' to the scallops of St. Brieuc Bay. They themselves express nothing. However they end up having, like the fishermen, an authentic spokesman. As we have seen, the negotiations between the scallops and the researchers revolve around one question: how many larvae can be trapped? The fact that this number should be retained as a principal subject of discussion is not a result of any absolute necessity. By counting the larvae, the three researchers wish to know what they can count on in their negotiations with their colleagues and the fishermen. Their interlocutors pay particular attention to the number of anchorages: the first to be convinced of the generality of the observation; the latter to be convinced of the efficiency of the device. How many electors came forward to choose their representatives: How many larvae anchored themselves on the collectors? This is the only question of any importance in either case. The anchorage is equivalent to a vote and the counting of anchored larvae corresponds to the tallying of ballots.[46] When spokesmen for the fishing community are elected the procedure is the same. From the fishing community which is just as silent as the scallops in the Bay, a few individuals come forward to slip their votes into the ballot boxes. The votes are counted and then divided between the different candidates: the analysis of these results leads to the designation of the official spokesman. Where are the differences in the case of the larvae? The larvae anchor themselves and are counted; the three researchers register these numbers on sheets of paper, convert these figures into curves and tables which are then used in an article or paper.[47] These results are analyzed and discussed during a conference and, if they are

judged to be significant, three researchers are authorized to speak legitimately for the scallops of St. Brieuc Bay: Pecten maximus does in fact go through an anchorage stage.

The symmetry is perfect. A series of intermediaries and equivalences are put into place which lead to the designation of the spokesman. In the case of the fishermen, the chain is a bit longer. This is because the professional delegates stand between the tallying of the vote and the three researchers. However, the result is the same: both the fishermen and the scallops end up being represented by the three researchers who speak and act in their name.[48] Although no vote is taken, the agreement of the scientific community is also based on the same type of general mechanism: the same cascade of intermediaries who little by little reduce the number of representative interlocutors. The few colleagues who attend the different conferences or seminars speak in the name of all the researchers involved.[49] Once the transaction is successfully accomplished, there are three individuals who, in the name of the specialists, speak in the name of the scallops and fishermen.

The schema below shows how entities as different as Pecten maximus, the fishermen of St. Brieuc and the community of specialists are constructed by interposed spokesmen.

Using the notion of spokesman for all the actors involved at different stages of the process of representation does not present any problem. To speak for others is to first silence those in whose name we speak. It is certainly very difficult to silence human beings in a definitive manner but it is more difficult to speak in the name of entities that do not possess an articulate language: this supposes the need for continuous adjustments and devices of interessement that are infinitely more sophisticated.[50]

Three men have become influential and are listened to because they have become the 'head' of several populations. They have mixed together learned experts, unpolished fishermen, and savoury crustaceans. These chains of intermediaries which result in a sole and ultimate spokesman can be described as the progressive mobilization of actors who render the following propositions credible and indisputable by forming alliances and acting as a unit of force: 'Pecten maximus anchors' and 'the fishermen want to restock the Bay'. The notion of mobilization is perfectly adapted to the mechanisms that we have described. This is because this term emphasizes all the necessary displacements. To mobilize, as the word indicates, is to render entities mobile which were not so beforehand. At first, the scallops, fishermen, and specialists were

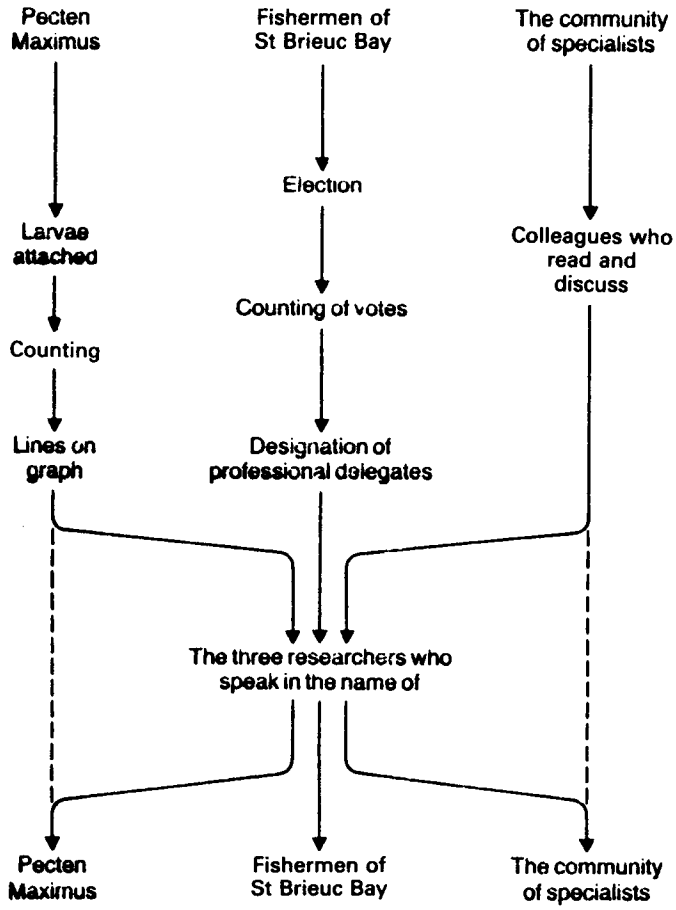

Figure 5

actually all dispersed and not easily accessible. At the end, three researchers at Brest said what these entities are and want. Through the designation of the successive spokesmen and the settlement of a series of equivalencies, all these actors are first displaced and then reassembled at a certain place at a particular time. This mobilization or concentration has a definite physical reality which is materialized through a series of displacements (Law, 1985b).

The scallops are transformed into larvae, the larvae into numbers, the numbers into tables and curves which represent easily transportable, reproducible, and diffusable sheets of paper

(Latour, 1985). Instead of exhibiting the larvae and the towlines to their colleagues at Brest, the three researchers show graphic representations and present mathematical analyses. The scallops have been displaced. They are transported into the conference room through a series of transformations. The choice of each new intermediary, of each new representative must also meet a double requirement: it renders each new displacement easier and it establishes equivalences which result in the designation of the three researchers as spokesmen. It is the same for the fishermen transformed into voting ballots and then professional delegates whose previously recorded points of view are reported to Brest.

The result which is obtained is striking. A handful of researchers discuss a few diagrams and a few tables with numbers in a closed room. But these discussions commit uncountable populations of silent actors: scallops, fishermen, and specialists who are all represented at Brest by a few spokesmen. These diverse populations have been mobilized. That is, they have been displaced from their homes to a conference room. They participate, through interposed representatives, in the negotiations over the anchorage of Pecten maximus and over the interests of the fishermen. The enrolment is transformed into active support. The scallops and the fishermen are on the side of the three researchers in an amphitheatre at the Oceanographic Centre of Brest one day in November 1974.

As this analysis shows, the groups or populations in whose name the spokesmen speak are elusive. The guarantor (or the referent) exists once the long chain of representatives has been put into place. It constitutes a result and not a starting point. Its consistency is strictly measured by the solidity of the equivalencies that have been put into place and the fidelity of a few rare and dispersed intermediaries who negotiate their representativity and their identity (Hennion, 1983). Of course, if the mobilization is successful, then:? Pecten maximus exists as a species which anchors itself; the fishermen want the repopulation and are ready to support the experimental project; colleagues agree that the results obtained are valid.[51] The social and natural 'reality' is a result of the generalized negotiation about the representativity of the spokesmen. If consensus is achieved, the margins of manoeuvre of each entity will then be tightly delimited. The initial problematization defined a series of negotiable hypotheses on identity, relationships and goals of the different actors. Now at the end of the four moments described, a constraining network of relationships has been built.[52] But this consensus and the alliances which it

implies can be contested at any moment. Translation becomes treason.

IV Dissidence: betrayals and controversies

During recent years, sociologists have devoted numerous studies to controversies and have shown the important role they play in the dynamics of science and technology. Why and in what conditions do controversies occur? How are they ended? The proposed schema of analysis makes it possible to examine these two questions in the same way. At the same time, this schema maintains the symmetry between controversies which pertain to Nature and those which pertain to Society.

Is a spokesman or an intermediary representative? This is a practical and not a theoretical question. It is asked in the same manner for the scallops, the fishermen and the scientific colleagues. Controversy is all the manifestations by which the representativity of the spokesman is questioned, discussed, negotiated, rejected, etc.

Let us start with the scallops. The first experiment or, if we use our vocabulary, act of interressement, mobilizes them in the form of larvae anchored to collectors and in the form of diagrams discussed at Brest before a learned assembly. This group established a fact: Pecten maximus anchors itself when in the larval state. About a hundred larvae gathered in nets off the coast of St. Brieuc were enough to convince the scientists that they reflect the behaviour of an uncountable number of their invisible and elusive brothers.

But is this movement likely to last? Will the scallops continue to anchor their larvae on the collectors generation after generation? This question is of crucial importance to our three researchers. It concerns the future of the restocking of the Bay, the future of the fishermen and, in consequence, their own future. The years pass and things change. The repeated experiment results in a catastrophe. The researchers place their nets but the collectors remain hopelessly empty. In principle the larvae anchor, in practice they refuse to enter the collectors. The difficult negotiations which were successful the first time fail in the following years. Perhaps the anchorages were accidental! The multiplicity of hostile interventions (this at least is the interpretation of the researchers in their role of spokesman for the scallops), the temperature of the water

layers, unexpected currents, all sorts of predators, epizooty, are used to explain why the interessement is being inefficient. The larvae detach themselves from the researchers' project and a crowd of other actors carry them away. The scallops become dissidents. The larvae which complied are betrayed by those they were thought to represent. The situation is identical to that of the rank and file which greets the results of Union negotiations with silent indignation: representivity is brought into question.[53]

This controversy over the representivity of the larvae which anchor themselves during the first year's experiments is joined by another: this time it is the fishermen. Their elected representatives had been enrolled in a long term programme aimed at restocking St. Brieuc Bay without a shadow of reservation and without a peep of doubt. In the two years following the first (and only) anchorages, the scallops hatched from the larvae 'interested' by the collectors, after being regrouped at the bottom of the bay in an area protected by a concrete belt, are shamelessly fished, one Christmas Eve, by a horde of fishermen who could no longer resist the temptation of a miraculous catch. Brutally, and without a word, they disavowed their spokesmen and their long term plans. They preferred, as in the famous aphorism of Lord Keynes, to satisfy their immediate desires rather than a hypothetical future reward.

Faced with these silent mutinies of scallops and fishermen, the strategy of the three researchers begins to wobble. Is anchorage an obligatory passage point? Even scientific colleagues get sceptical. The three researchers have now to deal with growing doubt on the part of their laboratory director and the organisations which had agreed to finance the experiment.

Not only does the state of beliefs fluctuate with a controversy but the identity and characteristics of the implicated actors change as well. (What do the fishermen really want? How does Pecten maximus behave?. . .). Nature and Society are put into place and transformed in the same movement.

By not changing the grid of analysis, the mechanisms of the closure of a controversy are now more easily understood. Closure occurs when the spokesmen are deemed to be beyond question. This result is generally obtained only after a series of negotiations of all sorts which could take quite some time. The scallops do not follow the first anchored larvae and the fishermen do not respect the commitments of their representatives; this leads the three researchers to transform the device of interessement used for the

scallops and their larvae and to undertake a vast campaign to educate and inform (i.e. form) the fishermen to choose other intermediaries and other representatives. It is at this point of their story that we leave them in order to examine the lessons that can be drawn from the proposed analysis.

V Concluding remarks

Throughout this study we have respected the three principles established in the introduction.

1) To comply with the first (generalized agnosticism) principle we looked at how the three researchers considered the facts of Nature and the social contexts which they elaborated and shaped. We faithfully reported doubts about society and the alliances that could be created. We were consequently able to treat uncertainties about the properties of scallops and uncertainties about fishermen and their interests in the same way.

In addition, and this enabled us to deal with the first difficulty revealed by recent studies in sociology of science, we systematically forced ourselves to judge neither the positions taken by the actors nor to reduce them to a particular 'sociological' interpretation. For example, the three researchers' belief in the anchorage of larvae or in the existence of a homogeneous group of fishermen with the same long term interests was never presented as an illusion or an error of judgment. The existence or the non-existence of the anchorage or of this social group may only be determined at the end of the course which was followed and it is the three researchers who reveal this through their different endeavours.

2) The second principle (generalized symmetry) compelled us not to change the grid of analysis in order to study controversies in connection with Nature and those in connection with Society. We have carefully followed this requirement by using the same vocabulary throughout. Problematization, interessement, enrolment, mobilization and dissidence (controversy-betrayal) are used for fishermen, for the scallops and for scientific colleagues. These terms are applied to all the actors without discrimination.

By following this procedure, we have avoided the second difficulty mentioned in the introduction. We did not use social

factors, norms, or particular institutional or organizational configurations to explain why discussions concerning the scallops or the fishermen took place or were closed. To establish, urbi et orbi, that larvae anchor, the complicity of the scallops is needed as much as that of the fishermen. These three categories of actors are all equally important. At no time can society be reduced to a balance of power or to a series of conditions in order to explain the growth and the closure of a controversy.

3) The third principle (free association), made it possible to follow all the variations which affected the alliances forged by the three researchers without locking them into fixed roles. Not only was the identity of the scallops or the fishermen and the representatives of their intermediaries or spokesmen (anchored larvae, professional delegates, etc.) allowed to fluctuate, but the unpredictable relationships between these different entities were also allowed to take their course. This was possible because no a priori category or relationship was used in the account. Who at the beginning of the story could have predicted that the anchorage of the scallops would have an influence on the fishermen? Who would have been able to guess the channels that this influence would pass through? These relationships become visible and plausible only after the event.

Thus the third difficulty was circumscribed without any problem. The story described here, although centered around the three researchers, did not bring in any actor that they themselves did not explicitly invoke nor did it impose any fixed definition on the entities which intervened.

Despite what might be judged a high degree of permissiveness in the analysis, the results were not an indescribable chaos. Certainly the actors studied were confronted with different types of uncertainties. The situation proposed for them here is much less comfortable than that which is generally given by the sociology of science. But their competences prove to be worthy of the difficulties they encountered. They worked incessantly on society and nature, defining and associating entities, in order to forge alliances that were confirmed to be stable only for a certain location at a particular time.

This methodological choice through which society is rendered as uncertain and disputable as nature, reveals an unusual reality which is accounted for quite faithfully by the vocabulary of translation.

First, the notion of translation emphasizes the continuity of the displacements and transformations which occur in this story: displacements of goals and interests, and also, displacements of devices, human beings, larvae and inscriptions. Displacements occurred at every stage. Some play a more strategic role than others. Displacements during the problematization: instead of pursuing their individual short term interests, the fishermen are invited to change the focus of their preoccupations and their projects in order to follow the investigations of the researchers. Displacements during the stage of interessement: the larvae falling to the sea floor or pushed along by the currents are deflected and intercepted by the nets. Displacements during the stage of enrolment where an agreement is found through mutual concessions: the collectors are moved to a new location to capture the larvae more effectively which have also attracted the researchers to their own terrain. Displacements, and these are essential, during the stage of mobilization: the larvae anchored to the collectors, the fishermen of St. Brieuc Bay, and the colleagues dispersed throughout the world are displaced to Brest after having changed their form and state in order to support the three researchers who claim to be their spokesmen. And finally, displacement during the final stage, that of dissidence: the fishermen penetrate the barriers and, refusing to follow the researchers, devastate the fish reserve; the scallops and their larvae avoid the nets that are meant to anchor them. Because of a series of unpredictable displacements, all the processes can be described as a translation which leads all the actors concerned as a result of various metamorphoses and transformations, to pass by the three researchers and their development project.

To translate is to displace: the three untiring researchers attempt to displace their allies to make them pass by Brest and their laboratories. But to translate is also to express in one's own language what others say and want, why they act in the way they do and how they associate with each other: it is to establish oneself as a spokesman. At the end of the process, if it is successful, only voices speaking in unison will be heard. The three researchers talk in the name of the scallops, the fishermen, and the scientific community. At the beginning these three universes were separate and had no means of communication with one another. At the end a discourse of certainty has unified them, or rather, has brought them into a relationship with one another in an intelligible manner. But this would not have been possible without the

different sorts of displacements and transformation presented above, the negotiations, and the adjustments that accompanied them. To designate these two inseparable mechanisms and their result, we use the word translation. The three researchers translated the fishermen, the scallops, and the scientific community.

Translation is a process before it is a result. That is why we have spoken of moments which in reality are never as distinct as they are in this paper. Each of them marks a progression in the negotiations which result in the designation of the legitimate spokesmen who, in this case study, say what the scallops want and need, and are not disavowed: the problematization, which was only a simple conjecture, was transformed into mobilization. Dissidence plays a different role since it brings into question some of the gains of the previous stages. The displacements and the spokesmen are challenged or refused. The actors implicated do not acknowledge their roles in this story nor the slow drift in which they had participated, in their opinion, wholeheartedly. As the aphorism says, traduttore-traditore, from translation to treason there is only a short step. It is this step that is taken in the last stage. New displacements take the place of the previous ones but these divert the actors from the obligatory passage points that had been imposed upon them. New spokesmen are heard that deny the representivity of the previous ones. Translation continues but the equilibrium has been modified. This is the case for the story which was presented here in which three researchers–spokesmen end up being denounced. At the same time, the description of the social and natural reality begins to fluctuate.

Translation is the mechanism by which the social and natural worlds progressively take form. The result is a situation in which certain entities control others. Understanding what sociologists generally call power relationships means describing the way in which actors are defined, associated and simultaneously obliged to remain faithful to their alliances. The repertoire of translation is not only designed to give a symmetrical and tolerant description of a complex process which constantly mixes together a variety of social and natural entities. It also permits an explanation of how a few obtain the right to express and to represent the many silent actors of the social and natural worlds they have mobilized.[54]

Notes

1 D. Bloor clearly defined the methodological principles which are now used in a growing number of social studies of science. They characterize what he calls the strong programme of sociology of science.

2 These empirical studies have concerned a wide variety of scientific fields. The most important are found in: K. Knorr, R. Krohn, R. Whitley (eds) (1980); particularly noteworthy in this book are the articles by T. Pinch and A. Pickering. Also the special issue of Social Studies of Science 11,1 (1981) was devoted to scientific controversies. See also; B. Barnes and S. Shapin (eds) (1979) and Wallis (ed.) (1979). A classic is H. M. Collins (1975). A good overview of these studies can be found in S. Shapin (1982).

3 This is affirmed most forcefully in the studies by the Edinburgh school of sociology (Barnes, 1978 and 1982; D. MacKenzie, 1978). A good overview of this sociology has been presented by J. Law and P. Lodge (1984). They demonstrate the rich relationships with the philosophy of Mary Hesse (1974). The ethnomethodologists and those who are close to them are not always directly concerned by this criticism. See for example the article by M. Lynch (1982) which explicitly admits the simultaneous construction of scientific facts and social context. His argument is used in M. Callon et al. (1984).

4 The belief in the existence of norms and their regulating role is one of the fundamental characteristics of Mertonian and post-Mertonian sociology which is itself linked to a more general functionalist or culturalist analysis of institutions (Merton, 1973). But this belief is explicitly or implicitly shared by a large number of epistemologists or philosophers of sciences. The postulate that a scientific method exists, no matter how it is characterized, leads necessarily to the idea of social or technical norms and consequently to a sociology which the sociologists themselves no longer believe in. As an example of an article in which norms are used as a determining variable, see C. Freudenthal (1984). The more one insists on the existence of scientific method, the more the sociology used is simple and out of date.

5 This is the case of Marxist inspired analysis (Yoxen, 1981).

6 Concerning the possibility of using the social sciences as a means of controlling other types of discourse, see the very critical analysis of M. Serres (Serres, 1980) and I. Stengers (Prigogine and Stengers, 1979).

7 The two major works of this type of literature remain the books of J. D. Watson (Watson, 1968) and T. Kidder (Kidder, 1982). Kidder's description is particularly interesting because even in a well identified market situation the major uncertainties are not only linked to the technical characteristics of the micro computer but also to the social relationships which are woven around it: 'They lived in a land of mists and mirrors. Mushroom management seemed to be practiced at all levels in their team. Or perhaps it was a version of Steve Walladh's ring protection system made flesh: West feeling uncertain about the team's real status upstairs; West's own managers never completely aware of all that their boss was up to; and the brand-new engineers kept almost completely ignorant of the real stakes, the politics, the intentions that lay behind what they were doing. But they proceeded headlong' (p. 105). A recent illustration of this literary style is supplied by B. Latour's analysis of Pasteur (Latour, 1984). In a field other than sociology of knowledge, L. Boltanski showed that the social

uncertainties and actor's sizes were at the heart of letters of denunciation sent to a major French evening newspaper (1984).

8 Do controversies concerning the constitution of society play as an important a role in the fundamental sciences as they do in applied or technical fields? Scientists debate the existence of solar neutrinos (T. Pinch, 1980 and 1981), charmed particles (A. Pickering, 1980) or the structure of TRF (B. Latour and S. Woolgar, 1979). Are they just as willing to call into question aspects of the social world which surrounds them? Technologists seem to have no trouble doing so (Callon, 1980; Pinch and Bijker, 1984). But what about scientists? Several answers could be given to this question. First, if the analysis of scientific controversies often seems to be confined to laboratories or scientific specialties, this is simply due to the fact that sociologists stop following their protagonists when they leave the scientific arena. Bahcall, Guillemin and Weber all have to find resources, organize teaching programmes, write manuals, create or control scientific journals if they want to succeed in their scientific activities. This activity takes place outside the laboratory but it largely determines the nature of science. It requires that researchers permanently formulate hypotheses concerning the identity and the goals of the people with whom they interact. This dimension of the social studies of science should not be ignored when seeking to explain the content of knowledge. Secondly the dynamic study of controversies shows that phases exist during which debates concern both society and knowledge (Shapin, 1979). This is notably the case when translation networks take shape and are negotiated (Callon, 1981). When these networks are consolidated the activities, roles and interests are differentiated and recognized. The controversies separate technical and scientific problems more and more frequently from their social contexts. But the separation is never totally achieved as long as the controversies continue because these imply the recruitment by the protagonists of outside and heterogeneous allies (administrators, industrialists, teachers. . .). A purely scientific controversy in which the protagonists did not undertake a 'sociological analysis' of the situation is a pure contradiction. Scientists can only agree on society if they are completely in agreement about scientific and technical issues. This can happen and in several ways: the sclerosis or total bureaucratization of a speciality (Crane, 1972); a political 'putsch' within a science which blocks technical controversies by blocking discussions about the social structure in which they develop (Lecourt, 1976).

9 This thesis is developed by Gouldner for sociology in general (Gouldner:1971). A good example of the endless controversies among sociologists about how to explain the development of science concerns the role of interests and their role in the construction and validation of knowledge. On this point see the critical analysis offered in Callon and Law (1982).

10 The classical problem of reflexivity may be posed in new terms as a result of developments in our understanding of controversy. Reflexivity is nothing more than an extension to the social sciences of the analysis that these offer for the construction of consensus within the natural sciences. Like nature, science cannot be invoked in order to explain the resolution of controversy and the construction of firm knowledge. There is no ultimate guarantee, no explanation in the last instance that cannot, in turn, be questioned. This does not mean, of course, that provisional consensus cannot be achieved. The argument that is being developed here is identical in form to that which made it possible for Popper (1934) to withdraw all logical status from induction.

11 J. Farley and G. Geison (1974).
12 Michel Callon (1981).
13 David Bloor (1976).
14 The argument developed here is similar in some respects to that advanced by Weber (1965). For Weber, the sociologist is guided by his own values (Wertbeziehung) and selects the problem to be studied and the elements of reality that seem to him to be most important. It is only once this reduction of an infinitely complex reality has been undertaken that the proper work of the sociologist can begin. The principle of generalised symmetry endows the sociologist-observer with analogous discretionary powers. In principle the choice of repertoire is entirely free. The only restriction is that it must relate both to nature and society.
15 John Law (1985b).
16 The notion of 'stock' is widely used in population demography. In the present case the stock designates the population of scallops living and reproducing in Saint-Brieuc Bay. A given stock is designated by a series of parameters that vary over time: overall number, cohorts, size, natural mortality rate, rate of reproduction, etc. Knowledge of the stock thus requires systematic measures which make it possible to forecast changes. In population dynamics mathematical models define the influence of a range of variables (e.g., intensity of fishing and the division of catch between cohorts) upon the development of the stock. Population dynamics is thus one of the essential tools for what specialists in the study of maritime fishing call the rational management of stocks.
17 For this study we had available all the articles, reports and accounts of meetings that related to the experiments at Saint-Brieuc and the domestication of scallops. About twenty interviews with leading protagonists were also undertaken.
18 CNEXO (Centre National d'Exploitation des Oceans) is a public body created at the beginning of the 1970s to undertake research designed to increase knowledge of and means of exploiting marine resources.
19 Two examples show the extent of the ignorance of both fishery professionals and fishermen. During the whole of the 1970s specialists disagreed – without ever undertaking any experiments – about whether scallops with temporary coral would conserve this feature if they were transplanted to areas where scallops have permanent coral. Again, fishermen claimed, contrary to the specialists, that scallops are able to move across the sea-bed. At the beginning of the 1980s a series of experiments was needed to resolve the first point. It was shown Scottish scallops with permanent coral retained this characteristic when moved to Saint-Brieuc Bay. On the second point, it was only with the assistance of video film that it was possible to convince the fishermen that such movement of scallops as there was was caused by currents.
20 As a result of the various alliances outlined above, in 1984 the fishermen earn about £25,000 a year (after expenses) for five hours work a week during six months of the year.
21 The term actor is used in the way that semioticians use the notion of the actant (Greimas and Courtes, 1979; Latour, 1984). For the implication of external actors in the construction of scientific knowledge or artefacts see the way in which Pinch and Bijker (1984) make use of the notion of a social group. The approach proposed here differs from this in various ways: first, as will be

suggested below, the list of actors is not restricted to social entities; but second, and most important, because the definition of groups, their identities and their wishes are all constantly negotiated during the process of translation. Therefore, these are not pregiven data, but take the form of an hypothesis (a problematisation) that is introduced by certain actors and is subsequently weakened, confirmed or transformed.

22 On the definition of constitutive unities see Latour and Strum (1985).

23 Marginal profit declines more or less rapidly as a function of the nature of stocks (dispersed or concentrated) and the demands of consumers. In the case of scallops these parameters combine to make capture of the last scallop profitable.

24 The reader should not impute anthropomorphism to these phrases! The reasons for the conduct of scallops – whether these lie in their genes, in divinely ordained schemes or anything else – matter little! The only thing that counts is the definition of their conduct by the various actors identified. The scallops are deemed to attach themselves just as fishermen are deemed to follow their short-term economic interests. They therefore act.

25 Barry Hindess (1982) has well demonstrated the negotiable character of interests. But it is necessary to go further: the identities of the actors themselves are open to question, as is the question of whether they are moved by values, interests or wishes. On this point see Michel Callon and John Law (1982).

26 For comparable analyses see Michel Callon (1981) and Bruno Latour (1984).

27 As can be discerned from its etymology, the word *problem* designates obstacles that are thrown across the path of an actor which hinder his movement. This term is thus used in a manner which differs entirely from that current in the philosophy of science and epistemology. Problems are not spontaneously generated by the state of knowledge or by the dynamics of progress in research. Rather they result from the definition and interrelation of actors that were not previously linked to one another. To problematise is simultaneously to define a series of actors and the obstacles which prevent them from attaining the goals or objectives that have been imputed to them. Problems, and the postulated equivalences between them, thus result from the interaction between a given actor and all the social and natural entities which it defines and for which it seems to become indispensable.

28 On the notion of association see Michel Callon and Bruno Latour (1981).

29 A fine example of such a change in state is to be found in Tracy Kidder (1982) where the computer can be seen taking shape in conversations which are converted into a paper computer which in turn is transformed into a network of cables and printed circuits. For a philosophical discussion of realisation and non-realisation see *Irreductions* (Latour, 1984).

30 This is without doubt the major lesson of Touraine's sociology. The actor does not exist outside the relationships which he enters. His identity fluctuates in parallel with them (Touraine:1974). In this he differs from Pierre Bourdieu (1972 and 1975) where the actor – whom he calls the agent – is defined in terms of certain fundamental properties.

31 Serres (1983) uses the notion of interest in a similar manner but the conclusions which he draws are entirely different. For him, interests sterilise knowledge because they come between the latter and its object. The apologue that he uses is magnificent (Alexander coming between Diogenes and his sun), but his

interpretation is false, as recent developments in the sociology of science have shown.

32 No hypothesis is offered here about the nature or size of A, B, C, D, E, . . . They may be social classes which mutually define one another (Touraine, 1974), father and son who tie their Oedipus complex, the elementary mechanisms of mimetic desire (Girard, 1982), or . . . scallops which are interested by researchers.

33 On the analysis of this process see L. Thevenot (1984) and his concept of investment in forms.

34 When the shell is formed it constitutes an effective shield against certain predators such as starfish.

35 Numerous analyses have made it clear that scientific argument may be seen as a device for interessement. See, amongst others, Michel Callon *et al.* (1983, 1984) Michel Callon, John Law and Arie Rip (eds) (1985), John Law (1983), John Law and Rob Williams (1982) and Bruno Latour (1984). Since this point is well established, details of the rhetorical mechanisms by which academics and fishermen were interested are not described in the present article.

36 For a systematic and penetrating outline of this style of analysis see Nadel (1970).

37 D. Buestel, J.-C. Dao, A. Muller-Fuega, 'Resultats preliminaires de l'experience de collecte de naissains de coquilles Saint-Jacques en rade de Brest et en baie de Saint-Brieuc' in Colloque sur l'aquaculture, Brest, Octobre 1973, *Actes de Coloque,* 1, (1974), CNEXO (ed.).

38 *Ibid.*

39 The description adopted here is not deliberately anthropomorphic in character. Just because currents intervene to thwart the experiments of researchers does not mean that we endow them with particular motives. Researchers sometimes use a vocabulary which suggests that starfish, climatic changes and currents have motives and intentions of their own. But it is precisely here that one sees the distance that separates the observer from the actor and the neutrality of the former with respect to the point of view of the latter. The vocabulary adopted, that of interessement and enrolment, makes it possible to follow the researchers in their struggles with those forces that oppose them without taking any view about the nature of the latter.

40 *Op. cit.*, note 37.

41 *Ibid.*

42 The discussions were recorded in reports which were made available.

43 One participant in the discussion, commenting on the report of Dao *et al.*, noted: 'At a theoretical level we must not minimise what we know already about scallops . . . It is important to remember that the biology of *pecten* was somewhat better known than you suggested.'

44 Dao: 'Obviously this is a very interesting observation. Our experience suggests that in general it is when the work has been done that tongues are loosened and we start to get information. For example, the fishermen had never seen scallops attached by a byssus. But since we have revealed that they are fixed in this way, they know where these are to be revealed, that they are fixed in this way, they know where these are to be found and they know where they were before. I believe that much the same thing is true for scientific information.' (*Ibid.*) On discussions about precursors and on the way in which credit is attributed to them, see in particular A. Brannigan (1979).

45 This is only a particular example of the general problem of induction.
46 Furthermore, right at the beginning of the experiments, the three researchers gathered the Saint Brieuc collectors together and transported them to their laboratory at Brest. Only after their arrival in Brest and in the presence of attentive colleagues, were the larvae extracted from the collectors, arrayed on a pallet somewhere near the Spanish Bridge, and counted. There is no difference between this and what happens after the polling stations close and the ballot-boxes are sealed. These are only reopened under the vigilant gaze of the scrutineers gathered round the tables upon which they are to be counted.
47 It needs to be shown in detail how to vote, that is to say an enumeration, whether this be of larvae or fishermen, can be transformed into an enrolment and relations of force. To do this would be to throw light upon the fundamental reasons for which (whether in politics or science) arithmetic plays a central role. This question will be further discussed in a future paper.
48 This general definition of representation throws light upon the notion of mental representation as this is used in cognitive psychology.
49 In the course of discussion the researcher whose opinions were constantly sought by the participants made this judgement: 'Let me underline the fact that this very remarkable communication marks an important date in our knowledge of the growth of Pecten maximus.'
50 This does not imply that all fishermen actively subscribe to the position adopted by their delegates. Rather it simply signifies that they do not interrupt the negotiations that those delegates undertake with the scientists and the larvae. As what subsequently happened reveals, interruption can occur without the fishermen explaining themselves publicly.
51 Following L. Thevenot (1984) one could there talk of 'investments of form'.
52 To describe the network of constraints and resources that results from a series of operations of translation I have proposed the concept of the actor-network (Callon:1985).
53 It is no surprise that the controversy or dispute was not explicitly voiced. Even electors sometimes 'vote with their feet'.
54 This point links with the notion of the political economy of power proposed by Michel Foucault (1976).

References

Barnes, Barry (1977), *Interests and the Growth of Knowledge*, Routledge & Kegan Paul, London.
Barnes, Barry (1982), *T.S. Kuhn and Social Science*, Macmillan, London.
Barnes, Barry and Shapin, S. (eds) (1979), *Natural Order: Historical Studies of Scientific Culture*, London and Beverly Hills, Sage Publications.
Bauin, Serge, Callon, M., Courtial, J.-P., *Le développement de l'aquaculture: analyse d'un système social complexe*, mimeo, CSI, 300p.
Bijker, Weibe, Pinch, T. and Hughes, T.P. (1986), *New Directions in the Social Study of Technology*, Cambridge, Mass., MIT Press.
Bloor, David (1976), *Knowledge and Social Imagery*, Routledge & Kegan Paul, London.
Boltanski, Luc (1984), 'La Dénonciation', *Actes de la Recherche en Sciences Sociales*, 51, 3–40.

Bourdieu, Pierre (1972), *Esquisse d'une théorie de la pratique*, Droz, Genève.
Bourdieu, Pierre (1975), 'The specificity of the scientific field and the social conditions of the progress of reason', *Social Science Information*, 14, 19–47.
Brannigan, A. (1979), 'The reification of Mendel', *Social Studies of Science*, 9, 423–54.
Callon, Michel (1980), 'Struggles and negotiations to define what is problematic and what is not; the socio-logic of translation', in K. D. Knorr and A. Cicourel (eds), *The Social Process of Scientific Investigation. Sociology of the Sciences Yearbook, Vol. 4*, D. Reidel Publishing Company.
Callon, Michel (1981), 'Pour une sociologie des controverses technologiques', *Fundamenta Scientiae*, 2, 381–399.
Callon, Michel (1985), 'The sociology of an actor-network', in: M. Callon, J. Law, A. Rip (eds).
Callon, Michel and Latour, Bruno (1981) 'Unscrewing the Big Leviathan: how actors macrostructure reality and how sociologists help them to do so', in K. Knorr Cetina and A. Cicourel (eds), *Advances in Social Theory and Methodology: Toward an Integration of Micro and Macro-Sociologies*, London, Routledge & Kegan Paul.
Callon, Michel and Law, John (1982), 'On interests and their transformation: enrolment and counter-enrolment', *Social Studies of Science*, 12, 615–625.
Callon, Michel, Courtial, J.-P., Turner, W. and Bauin, S. (1983), 'From translation to problematic networks: an introduction to co-word analysis', *Social Science Information*, 22, 191–235.
Callon, Michel, Bastide, F., Bauin, S., Courtial, J.-P. and Turner, W. (1984) 'Les mécanismes d'intéressement dans les textes scientifiques', *Cahiers STS-CNRS*, 4, 88–105.
Callon, Michel, Law, J. and Rip, A.(eds) (1985), *Texts and their Powers: Mapping the Dynamics of Science and Technology*, Macmillan, London.
Collins, H.M. (1975), 'The seven sexes: a study in the sociology of a phenomenon, or the replication of experiments in physics', *Sociology*, 9, 205–224.
Crane, Diana (1972), *Invisible Colleges*, Chicago, University of Chicago Press.
Farley, John and Geison, Gerald (1974), 'Science, politics and spontaneous generation in nineteenth-century France: the Pasteur-Pouchet Debate', *Bulletin of History of Medicine*, 48, 161–198.
Foucault, Michel (1976), *Surveiller et punir, Naissance de la Prison*, Gallimard, Paris.
Freudenthal, Gad (1984), 'The role of shared knowledge and science: the failure of the constructivist programme in the sociology of science', *Social Studies of Science*, 14, 285–95.
Girard, René (1961), *Mensonge romantique et vérité romanesque*, Grasset, Paris.
Girard, René (1982), *Le bouc émissaire*, Grasset, Paris.
Gouldner, A.W. (1971), *The Coming Crisis of Western Sociology*, Heinemann, London.
Greimas, A.J. and Courtes, J. (1979), *Sémiotique: dictionnaire raisonné de la théorie du langage*, Hachette, Paris.
Hennion, Antoine (1983), 'Une sociologie de l'intermédiaire: le cas du directeur artistique de variétés', *Sociologie du Travail*, 4, 435–453.
Hesse, Mary B. (1974), *The Structure of Scientific Inference*, Macmillan, London.
Hindess, Barry (1982), 'Power, interests and the outcomes of struggles', *Sociology*, 16, 498–511.

Kidder, Tracy (1982), *The Soul of a New Machine*, Penguin Books.
Knorr, K.D., Krohn, R., Whitley, R. (eds) (1980), *Sociology of the Sciences Yearbook 4: the social process of scientific investigation*, Dordrecht, London and Boston, Mass, Reidel.
Latour, Bruno (1984), *Les microbes, guerre et paix, followed by Irréductions*, A. M. Métailié, Paris.
Latour, Bruno (1985), 'Visualisation and Cognition', H. Kuclick (ed.), *Sociology of Knowledge, Science and Art*, forthcoming.
Latour, Bruno and Strum, S. (1985), 'Human social origins: please tell us another origin story', *Journal of Biological and Social Structure*, in press.
Latour, Bruno and Woolgar, S. (1979), *Laboratory Life: the Social Construction of Scientific facts*, London and Beverly Hills, Sage.
Law, John (1983), 'Enrôlement et contre-enrôlement: les luttes pour la publication d'un article scientifique', *Social Science Information*, 22, 237–251.
Law, John (1985a), 'Technology, closure and heterogeneous engineering: the case of the Portuguese expansion', in Bijker, W., Pinch, T. and Hughes, T.P.
Law, John (1985b), 'On the methods of long distance control: vessels, navigation, and the Portuguese route to India', this volume.
Law, John and Lodge, P. (1984), *Science for Social Scientists*, London, Macmillan.
Law, John and Williams, R. (1982), 'Putting facts together: a study in scientific persuasion', *Social Studies of Science*, 12, 535–558.
Lecourt, D. (1976), *Lyssenko, Histoire réelle d'une 'Science prolétarienne'*, Maspero, Paris.
Lynch, M. (1982), 'Technical work and critical inquiry: investigations in a scientific laboratory', *Social Studies of Science*, 12, 499–534.
MacKenzie, D. (1978), 'Statistical theory and social interests: a case study', *Social Studies of Science*, 8, 35–83.
Merton, Robert K. (1973), *The Sociology of Science, Theoretical and Empirical Investigations*, The University of Chicago Press, Chicago.
Nadel, Sigfried F. (1970), *La théorie de la structure sociale*, Editions de Minuit, Paris.
Pickering, A. (1980), 'The role of interests in high-energy physics: the choice between charm and colour', in K. D. Knorr, R. Krohn and R. Whitley (eds) (1980).
Pinch, Trevor J. (1980), 'Theoreticians and the production of experimental anomaly: the case of solar neutrinos', in K. D. Knorr, R. Krohn and R. Whitley (eds) (1980).
Pinch, T.J. (1981), 'The Sun-set: the presentation of certainty', *Social Studies of Science*, 11, 131–158.
Pinch, T.J. and Bijker, W. (1984), 'The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other', *Social Studies of Science*, 14, 399–441.
Popper, K. (1934), *Logik der Forschung*, Springer, Vienna.
Prigogine, I. and Stengers, I. (1979), *La nouvelle alliance*, Gallimard, Paris.
Serres, Michel (1980), *Hermes V: Le passage du Nord-Ouest*, Editions de Minuit, Paris.
Serres, Michel (1983), *Détachement*, Flammarion, Paris.
Shapin, S. (1979), 'The politics of observation: cerebral anatomy and social interests in the Edinburgh phrenology disputes', in R. Wallis (ed.).
Shapin, S. (1982), 'History of science and its sociological reconstructions', *History*

of Science, 20, 157–211.
Touraine, A. (1974), *Production de la Société*, Seuil, Paris.
Thevenot, A. (1984), 'Rules and implements: investment in forms', *Social Science Information*, 23, 1–45.
Wallis, R. (ed.) (1979), *On the Margins of Science: the Social Construction of Rejected Knowledge*, Keele, University of Keele (Sociological Review Monograph 27).
Watson, James D. (1968), *The Double Helix*, Mentor Book, N.Y.
Weber, M. (1965), *Essais sur la théorie de la science*, Plon, Paris.
Young, Robert and Levidov, L. (eds) (1981), *Science, Technology and the Labour Process*, CSE Books, London.
Yoxen, E. (1981), 'Life as a productive force: capitalising the science and technology of molecular biology', in Young, R. and Levidov, L. (1981).