Niche Practices in the Upstream Petroleum Industry[1]

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Abstract

We identify three approaches to understanding niches: (1) the wellspring as a stable ecology where resources are exogenously defined, (2) the firm's forte as a specific location created by a company in its development and use of resources, and (3) emergence through collective discovery as a site of novelty through interacting resources across different agents. We assess the tractability of these three approaches empirically in assessing the exploration, development and production activities in deepwater in the US Gulf of Mexico. Niches are distinct from clusters. Niches exhibit extensive bounds at particular moments in time and temporal bounds in which endogenous tendencies foresee their demise. The resources of niches develop through interacting both autonomously and through agents' deliberation in realising entrepreneurial plans through experimental activities. We find that Approach (2) is most convincing in capturing the early phases in forming a niche, with Approach (3) being more visible towards its end, although neither captures the niche exclusively. Approach (1) is more appropriate to clusters. Geels (2002) envisages a break between an established socio-technical regime or cluster and a niche, with the niche being an experimental location from which the socio-technical regime selects among proto-technological trajectories. In contrast, we find communication and continuation between the realms of the niche and the socio-technical regime.

Keywords: niche, upstream petroleum industry, experimental organisation, resources

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Introduction

This paper has two aims, one empirical and the other in developing theory. Empirically, we seek to explain the development of the deepwater sector of the international upstream industry, specifically offshore in the US Gulf of Mexico. The upstream industry involves prospecting for hydrocarbon resources and developing these into production facilities or projects. Theoretically, we seek to develop the concept of the niche longitudinally, as an ecological and evolutionary framework, to capture the intermingling of internal and external economies created and exhausted in a distinct type of business activity (Kemp et al. 1998, Geels 2002). We are undertaking empirical analysis within a broadly evolutionary framework and at the same time drawing upon our empirical analysis to question, develop and extend this framework.

There have been a large number of empirical studies undertaken with reference to ecologies and niches, dating from Hannan and Freeman (1977) and summarised as organizational ecology (Hannan and Freeman 1989) and industrial demography (Carroll and Hannan 2000). Our study differs from these in being explicitly longitudinal and also by focussing on factors endogenous to the niche in explaining the development of the niche alongside its constituent companies. Rather than assuming that the niche is a stable entity within which companies can adopt one of a range of competitive strategies, we see the niche itself as a developing entity, influenced by the entry and exit decisions of companies as well as by the strategies that companies adopt in situ. It may be difficult to discern something with the implied stable identity of strategy anyway given that we think, following Geels (2002), that a niche is an entity that can support novel and experimental activities.

At the same time, we develop our concept of niche in distinction to the broader notion of cluster (Storper 1997, Maskell 2001, Cumbers et al. 2003). Clusters comprise horizontal and vertical connections or relationships in the exchange and development of knowledge through co-location. The dominant trajectory in our explanation is of the niche providing temporal boundaries in knowledge exchange and development. Clusters are also often examined from the perspective of co-locating firms and their abilities to benefit from Marshallian external economies. The dimensions of a cluster as a distinct unit of analysis are less often a focus of inquiry. It is our contention that a cluster or (more generally) an industry can outlive a niche, but that a niche provides temporal and organisational bases for a phase in the development of an industry and of some firms in that industry.

Finally, the niche is one way of bringing together the distinct analytical entities of firm and industry as different levels. Some recent contributions have outlined a co-evolutionary approach to industrial development (Nelson 1995, Lewin and Volberda 1999, Volberda and Lewin 2001). Niches are an arena within which firms may be selected and at the same time can undertake selections experimentally (Kemp et al. 1998, Loasby 2002). We draw upon Geels's (2002) study of shipbuilding and Huygens et al.'s (2001) study of the recorded music industry, particularly as these address interactions across different levels of entities, in guiding our research process.

Our case study of deepwater exploration in the Gulf of Mexico offers a unique basis to focus on the temporal dimension of niches, which we see as an essential feature. Irrespective of whether we approach the deepwater study from the perspective of industry or firm, there are four important dimensions around which we can understand its development: geology, technology, social and economic organisation and state regulation. Two of these – geology and state regulation – are specific to the US Gulf of Mexico and so provide durable bounds that distinguish deepwater exploration in deepwater sector of the Gulf of Mexico as a niche. Arguably, other cases and episodes of industrial development, whether characterised as niches or clusters, have less durable aspects to their boundaries, such as the spatial characteristics or intended customers in cities.

The paper is organised into five further sections. In the following section we set out our temporal and broadly evolutionary understanding of niches in distinction to the established ecological framings of niches and also to clusters. In Section Three we explain our research process, with a focus on how we adapt our temporal understanding of niches to cope with the interactions between firm and industry levels. Section Four provides an empirical assessment of the development of the deepwater exploration and production in the Gulf of Mexico. We present five case studies from the perspectives of companies involved in deepwater exploration in Section Five. Section Six concludes by identifying temporal tendencies of the extension and exhaustion of niches relative to what may be more durable agencies of cluster and industry.

Niches. From Ecology to Evolution via Shaping Economic Resources

The aim of this section is to establish a view of the niche as an analytical concept which is broadly evolutionary and longitudinal as well as ecological. At the outset, our concept of niche shares with

those already established in industrial demography and also in research into clusters the placing bounds both for agents and for researchers when discussing any given period of strategic episode. The bounds of niches will involve delimiting, for example, relevant potential and actual customers, suppliers and rivals. Niches can imply safe havens (Chamberlin 1933, Tisdell and Seidl 2004), slightly safer havens (Marshall 1919, 1920), or areas for experimentation and novelty, awaiting development on a larger scale (Kemp et al. 1998, Geels 2002). Our understanding of niches also shares some bases from agents' perspectives in the early research on satisficing within companies and on the bounded rationality of agents (Cyert and March 1963; Nelson and Winter 1982).

Rather than accepting the niche as a given or stable boundary or an entity that implies a boundary functionally, we seek to assess how a niche can develop over time as a distinct level of analysis, and in part endogenously through the interaction of its set of constituents. We think a niche's constituents, which are in general resources, will change intrinsically through interaction and experimentation within the niche (Håkansson and Waluszuwski 2002), and extrinsically through entry and exit into the niche (Carroll and Hannan 2000). In this sense, our explanation of the niche can also be described as co-evolutionary. Simon (1983, pp. 46-47) makes a similar distinction, between a fixed supply of niches and one in which agents through their activities can develop niches.

Our main mode of argument is analogical and abductive (Dubois and Gadde 2002). Where ecology and evolution are rival theories of speciation among some prominent biologists (Ridley 1996, p. 410), evolutionary arguments have pursued both strictly Darwinian and more broadly developmental agenda among social scientists (Loasby 2002). Hannan and Freeman (1977, p. 947) draw upon an established definition among biologists of the niche – from Hutchinson (1957) – as a starting point:

> The (realized) niche of a population is identified as the area in constraint space (the space whose dimensions are levels of resources, etc.) in which the population outcompetes all other local populations. The niche, then, consists of all those combination of resource levels at which the population can survive and reproduce itself.

This definition is capable of supporting different applications of niches to companies and industries. For instance, Young (1988) takes a counter-analogical view and criticises Hannan and Freeman's analogical use of "ecology" and "niche" for conflating the biological sense of species with the statistical sense of representing a species as a population. Young's counter-analogical stance would find support among other proponents of literal applications (Hodgson 2002). Our interest rather is in comparing the definition that has been influential for Hannan and Freeman with economic, corporate and industrial meanings of resources (or capabilities) (Penrose 1959, Richardson 1972, Loasby 1998).

We share with Hannan and Freeman their interests in a niche being a distinct and somehow bounded space within a broader economic system and also of a niche being configured or realisable in different ways (Loasby 1976, Potts 2000). If resources are given, so distinct from populations and pre-existing any entries into a niche, any subsequent analysis is in the Marshallian short-period. It implies that other populations can have different technologies for combining resources, including those of suppliers and customers. Resources can be exhaustible, but the approach of industrial demography seems to be one of resources being autonomously or exogenously self-renewing. The critical dynamic is of different populations emerging with different strategies for undertaking activities to produce what are, from some end user's perspective, substitutable products. One such distinction is 'niche-width', which translates roughly into companies following a strategy of either narrow specialist or broad generalist (Freeman and Hannan 1983).

By inference, there must be external economies pertaining to the niche (or more accurately, having already pertained to the niche), such as open-source knowledge of the technologies and organisational means required (as resources close-at-hand to companies). Open source is required for companies in populations to select narrow or broad niche widths, given further information about supplier capacities and end-user preferences. These too are interpreted as parameters and pre-exist any phase of analysis.

Podolny et al. (1996) introduce a significant development to the industrial demography approach by relaxing the analytical mode of companies which organise into a small number of populations. Resources are still 'externally given' but assumed heterogeneity among units of analysis, including companies as well as populations, allows for companies to go about 'finding their own niches' as unique positions in a 'technology space' (ibid., p. 662). Podolny et al. still refer to objective and stable resources as markers of niche spaces so that a population comes to possess 'niche overlaps' across multiple domains such as production technology and product marketing. So a niche can be unoccupied or formally unrealised, or can become isomorphic with a company that comes to occupy a position defined by objective and stable resources. From here, we could have a basis for

'history-friendly modelling' or simulation (Malerba et al. 1999 2001). Companies could be assigned at random search draws with different chances of success relating to different positions in technology space (Nelson and Winter 1982). What we are missing though are explanations of how companies become heterogeneous – being distinct from one another – and how this heterogeneity is maintained or threatened in the context of a niche and in relation to other companies (Nelson 1991).

Penrose's (1959) explanation of companies is of bundles of resources, which are activated or transformed into flows of productive services made complementary around a managerial vision of a product. The explanation is inherently subjective. A resource is so by virtue of its capacity to provide a flow of services, which in turn is so given an entrepreneurial plan realised as an experiment. In a radically subjectivist explanation commodities or ubiquities can be acquired from suppliers under simple exchange relationships, contracts, guarantees and instructions in use. Commodities or ubiquities acquire the status of resource through connection (that is, interpretation and capture) with other resources as sets of productive services made complementary in realising an entrepreneurial plan. Resources acquire value in context. This is a different understanding of resources than implied in the citation (above) of ecology, population and niche selected by Hannan and Freeman (1977). Despite Young's (1988) criticism, Hannan and Freeman are being too conservative in 'abducting' their ecological analogy. At least some economic resources that characterise a niche are produced and reproduced by companies in the process of addressing managers' entrepreneurial plans.

This is not to imply that resource levels are unbounded. Penrose (1959) draws upon the counter-balances of resource creation through the capture of productive services becoming routine, and resource limitations through managerial capacity. Following Menger (1976), a resource is not so until it has an economic value such as being envisaged by and connected with an entrepreneurial plan. In effect, resources can support different streams of productive services, subject to managers' abilities to propose new business experiments in the form of entrepreneurial plans. This is subject to a further or higher-order constraint in that managers are assumed to work in teams, with it taking time, learning and resources to extend managerial capacity and free-up other managerial resources, even as old experiments become routine (or are abandoned). In contemporary terms, the layers of resources can be termed higher-order, indirect or dynamic capabilities (Teece et al. 1997, Loasby 1998, Eisenhardt and Martin 2000, Rindova and Kotha 2001, Adner and Helfat 2003, Winter 2003).

Penrose provides an explanation of the resource levels in a niche existing through the activities of individual and heterogeneous companies. Resources are reproduced over time and the rate of reproduction is influence by the higher-order, indirect or dynamic capabilities of companies. So many resources are available only to individual companies that we have a view of companies being their own niches. As with Chamberlin (1933), companies face the difficulty of devising more and more entrepreneurial plans in order that their resources can be used effectively in supporting flows of productive services. If Penrosian resources are the dominant type, this is not the essence of a niche as there is little sense in which companies are dependent upon one another. Any niches must be elsewhere, either prior to the company developing and practicing an entrepreneurial plan as an experiment and/or in terms of finding outlets for their products, but in between these upstream and downstream concerns, companies are islands (White 1981 2002). From a radical subjectivist perspective companies are islands in the vertical sense too, as commodities or ubiquities become resources in connection with an entrepreneurial plan and products are commodities or ubiquities in waiting, in the expectation of there being an entrepreneurial plan for the next user downstream.

Richardson (1972) asserts that 'no firm is an island' and proceeds to adopt some of Penrose's distinctions, with his notion of capabilities and activities being similar to Penrose's resources and productive services, respectively. Penrose captures dis-similar capabilities in a ranking or hierarchy of direct to indirect or operational to managerial within a company. Richardson allows for a more problematic coordination between different companies' dis-similar capabilities and highly complementary sub-activities required to undertake an overall productive activity (Dubois 1998). Håkansson and Waluszewski (2002, pp. 34-38) summarise and develop further an established approach of IMP research in identifying four categories of resources. In so doing they initiate processes or tendencies towards the objectification of resources, if not as commodities or ubiquities. Resources can be in the form of: products, especially from the perspective of the next user downstream; facilities, as a specification and so selection of some dimensions given some planned activities; business units, as the social organizing of uses and re-uses among similar capabilities in proposing and undertaking sub-activities; and business relationships, as means of addressing the social coordination of dis-similar capabilities in order to undertake both productive activities and commercial exchanges.

Considering resources as endogenous and developing is not equivalent to making resources objects, commodities or ubiquities, as may be inferred from the ecological definition adopted by

Hannan and Freeman (1977). We are not proposing that resources are just lying around, awaiting acquisition through simple commercial exchange. The essence of the resource is not captured either with respect only to an entrepreneurial plan within a company. Rather, entrepreneurial plans imply dependencies, relationships, rivalries and other forms of connection. In bringing time into their argument, Håkansson and Waluszewski (2002) are able to argue that resources are connected together selectively and interactively.[2] Detailed understandings of resources are formed relatively or comparatively such that some experimental activity can change the capacity of a resource and so change the relative capacities of other resources, be they similar or dis-similar. Likewise, the experimental entry of a resource new to a niche changes the relative standings of other similar and dis-similar resources.

We have identified three explanations of resources. Whichever exhibits empirical tractability will have a strong influence on the form and function of a niche. Resources may be: (1) distinct from companies or populations of companies and embody the properties of open source; (2) developed within companies subject to entrepreneurial plans being enacted through combinations of productive services; or (3) developed within networks interactively, in which companies are a location for entrepreneurial plans, but of only some of the resources required for enacting those plans. We need to identify which of these explanations best fits our empirical case of deepwater exploration and production in the Gulf of Mexico, why this is so, and what implications this has for our understanding of a niche. It is also of interest to identify any practical consequences of agents adopting other explanations.

We have one other empirical question to formulate in order that we can both characterise a niche and take this characterisation forward in understanding how this affects the role of resources. Ecologies presume boundaries, mainly in a spatial sense or in the sense of bounds to search for a given planning period (Tisdell and Seidl 2004). Rarely are temporal bounds considered. Geels (2002) is unusual in proposing an explanation of how niches are sites of experiments in which some experiments result in technological transitions that migrate into socio-technical regimes. A niche is a distinct level of analysis has similar characteristics to clusters (Dopfer et al. 2004). We propose that both types of boundary are essential to defining a niche and undertaking and empirical investigation drawing upon niches. Maskell (2001) and Maskell and Kebir (2005) are critical of researchers in the more general clusters approach for failing to reflect upon the extension of the cluster and the conditions of its demise. Niches are distinct from clusters in that they provide, at least following our interpretation, bases for explaining both extensions and temporal limits.

Networks imply entities being connected to further entities (Easton 1992, Holmen and Pedersen 2003). The recognition of time makes agents (including, for instance companies, business units within companies and government regulators) both forward-looking in terms of devising entrepreneurial plans and expressing and organising these as experiments, and backward-looking in terms of drawing upon resources and capabilities as repositories of past experiments and activities. Deepwater exploration and production is a problem around which entrepreneurial plans and experiments can be formulated (Flaherty 2000). Experimentation is a first-order condition and extension for identifying a niche. By contrast, Maskell (2001) argues that the first-order extension (and so condition) for identifying a cluster is (external) economies of co-location or of agglomeration. These were envisaged by Marshall in his explanation of industrial districts, with the extension restricted by the rise of diseconomies of co-location such as congestion. The two may be linked, for instance if a dense network provides so many interactions across resources that they overwhelm agents. This indicates that in a networks and connectivity sense, the difference between niches and clusters is one of degree and not type.

Research Process

Our research process aims at developing the concept of niche in a broadly evolutionary as well as ecological sense by means of an empirical inquiry. In order to address the two research questions identified in Section 2 (above), concerning the nature of resources in a niche and the temporal boundaries of niches, we undertake an analysis by case study of the development of deepwater exploration and production activities in the Gulf of Mexico (Ragin and Becker 1992, Acha and Finch 2005). We have argued that a niche provides a basis in theory for understanding the function of bounds for economic activities by means of developing, connecting and selecting economic resources.

[2] An advantage of a (complex) network structure for interactive resources is that it can localise interactions among resources (Easton 1992, Kauffman 1993, Potts 2000). We cannot go so far as to assert a neat and also (in a network sense, simple) modular structure (Simon 1962, Sanchez and Mahoney 1996, Langlois 2002). Furthermore, systems integrators are likely to be local experimenters in order that they can also be coordinators (Brusoni and Prencipe 2001).

Further we cannot assume that these bounds and resources are stable over time. Rather the bounds are as much part of the empirical inquiry as the economic resources and activities, such that a niche and its constituent resources are mutually constitutive or co-evolving (Nelson 1995, Lewin and Volberda 1999, Volberda and Lewin 2003). Where the empirical industrial demography studies and White's (1981 2002) studies of markets have taken the niche as a stable parameter, we seek to keep two levels and types of analysis – resources and niches – in view.

Two recent studies, which as far as we know are unique in attempting a longitudinal analysis in which interaction at two levels is a focus of inquiry, have shaped our research process: Huygens et al.'s (2001) study of the recorded music industry and Geels's (2002) study of technology transitions in the shipbuilding industry. Both studies are historical and longitudinal. The continuous comparison of company cases within the overall industry must take into account the longitudinal nature of their phenomena and interaction affecting each company (or business unit therein) over time even if it is present throughout long periods of the industry study, as well as the effects of entries and exits.

Geels' (2002, pp. 1263-70) argues that shipbuilding over the period 1780 to 1900 is an example of a technological transition. Huygens et al. (2001) present a similar appreciative analysis of the recorded music industry from 1900 to 1986, although they are clearer in distinguishing the industry as one level of analysis and strategic interaction among companies as another level of analysis. Both Geels (2002) and Huygens et al. (2001) emphasise coherent historical narrative and appreciative theorising. There is an emphasis on structural breaks that could threaten the coherent narrative or 'temporal bracketing' (Langley 1999, p. 703). That the narratives are shown to persist in both studies supports Geels' model of niches interacting with durable though not static socio-technical regimes. Indeed functionally, niches may be a means of protecting the narrative's coherence both among industrial agents and researchers (Kemp et al. 1998). There is less of an emphasis on breaking up these narratives into the perspectives of different agents with their own distinct contexts, if not distinct niches.

We take the idea of continuous comparison from the grounded theory contributions of Glaser and Strauss (1967) and Glaser (1978, 1992). Clearly though, our discussion has made clear an identification with distinct theoretical approaches to niches, theory resources and their boundaries. This sits uneasily with established understandings of grounded theory. We are not testing hypotheses and do not regard the established contributions as sufficiently mature to yield precise hypotheses that could test those contributions; hence our emphasis on ecological analogy and on deriving open research questions rather than precise hypotheses.

Continuous comparison rarely takes into account the notion of time in an intrinsic manner and in its more positivistic versions approximates variance rather than process theory (Langley 1999, Alvesson and Sjkolberg 2000). Time might emerge through coding as a dimension, but subjects of comparison are usually collocated in a time frame. Unlike, say, time series econometrics, longitudinal case study analysis by means of continuous comparison across cases is in its infancy (Pettigrew et al. 2001). The ultimate purpose of continuous comparison is generalisation (Leonard-Barton 1990). This is qualified though. Grounded theorists are aware of the tension between generalisation by means of undertaking comparisons across different contexts, situations or locations, and at the same time remaining faithful to those contexts. Hence, the broad view that grounded theory (of which we focus in this study on continuous comparison) inevitably leads to theories and knowledge-claims in the "mid-range" or of "substantive" nature.

In Langley's (1999) terms, Leonard-Barton's (1990) combination of single-site longitudinal analysis and multiple-site retrospective analysis is variational rather than processual. Despite this, Leonard-Barton's study has some commonalities with our research process. We undertook two case studies (BP and ARCO) in 1998 that focused on the technological and organisational dimensions of deepwater exploration and production, influenced by Acha's (2002) cognitive approach to technological frames. We drew upon face-to-face interviews supported by company annual reports and articles from industry journals. This led us to investigate the characteristics of deepwater as a distinct and still novel activity within the upstream petroleum industry historically. One of the two cases (BP) involved an early entrant into deepwater exploration and production in the Gulf of Mexico, so we supplemented our material with earlier company reports and industry publications.

We identified other company cases as being influential at particular times during the development of deepwater exploration and production in the Gulf of Mexico. Royal Dutch Shell (hereafter, Shell) was the pioneering company. Conoco was an early entrant, despite being a smaller company than Shell and BP. We developed case studies of these companies retrospectively and through company reports and industry journals including the four biennale reports of the US Mineral Management Service (the regulatory and licensing authority). While there is ample secondary data

about Shell's pioneering role, there is less information about Conoco's role, so we undertook a retrospective interview with someone who was a middle-manager at Conoco during the mid-1980s.

We undertook two further case studies during 2003 in order to capture the current state of deepwater exploration and production involving two face-to-face interviews with middle-managers from Woodside Energy and one face-to-face interview with an exploration manager of Statoil. Both were combined with annual reports and further articles in industry journals. Woodside was selected as a late entrant into deepwater exploration in the Gulf of Mexico and Statoil was selected as company that possessed appropriate technical capabilities but had not undertaken significant entry. Finally, we tested out some of our emerging understandings of the industry by interviewing an expert on deepwater activities employed by an international consultancy company.

Given an initial understanding of deepwater activities, we selected the case in the expectation that they would emphasise a phase in the development in the niche. The face-to-face interviews were undertaken in order to gain each company's perspective on deepwater exploration and production at that time. The interviews were historical as well as forward-looking, concerned technological and organisational practices, and extended beyond the immediate company to consider roles of other oil companies, services companies and the role of industry organisations and the regulator. We are aware of the potential dangers of retrospective interviews and also the retrospective parts of otherwise contemporary interviews. We were equally committed to documented sources, including company reports, industry journals and the biennial reports of the US Minerals Management Service. The one solely retrospective interview was more structured than the other face-to-face interviews and sought to fill in the gaps in our readings of documents about Conoco's deepwater activities in the 1980s.

The Bounds of the Deepwater Niche

In Section 2, we identified three approaches to niches (summarised in Table 1, below).

[Table 1 about here]

Approaches (1) and (3) envisage niches differently but conceptually as unified entities. Approach (2), given its inherent subjectivity, envisages niches that are specific to agents (in this case, companies or business units). As researchers, and adopting the analytical techniques and representations of clusters or networks, we can make some claims as to closeness between and connectivity across agents. These claims are means in the direction of objectification but would not support the niche as a unified entity. If there were significant spill-overs and interdependencies between agents as companies, we should replace approach (2) with either approach (1) or (3).

We can infer from approaches (2) and (3) that niches (at least given inquiry within the social sciences) are not simply and objectively "out there" awaiting discovery and occupation. Geels (2002) outlines a process by which a niche emerges from larger and durable industrial entity, which he describes as a 'socio-technical regime' (similar to an industrial cluster), with the capacity to affect a 'technological (and so social) transformation'. Following Marshall (1919, 1920) and Rafaelli (2004), we could expect the cluster or socio-technical regime to be a site of gradual technical improvement, with the regime or cluster guaranteeing some access to resources and the social dimension providing some form of conservatism or inertia as a means of coordination. A niche is more dramatic and potentially Schumpeterian as a means of promoting creative destruction (Pavitt 1998). In addition to identifying the processes by which niches are articulated among agents we need to specify the processes of its demise. In other words, we seek to specify the niche's temporal extension and bounds (Maskell and Kebir 2005).

Regulation and Licensing in the US Gulf of Mexico and Brazil's Campos Basin

A starting point is the US Minerals Management Service (MMS). Its very existence is an embodiment of territorial, spatial and temporal elements of a broader industrial cluster as well as a niche. As an agent, it has promoted deepwater exploration and production within an area of its jurisdiction in the Gulf of Mexico. The MMS's regulatory and licensing role also gives it the dual role of a resource and agent in overseeing bidding processes among other agents (oil companies) for licenses to undertake exploration activities in blocks of – in this case – the outer continental shelf. Neither the MMS nor the oil companies that participate in the licensing rounds know the extent of any hydrocarbon reserves pertaining to these exploration rights and so for all concerned this is an experimental activity, which can be described as prospecting. Over time evidence has accumulated in two and three-dimensional

seismic data, in geological models based to some extent on analogies of passed successful and unsuccessful exploration activities and in records of prices of bids.

A comparison can be made with deepwater exploration and production in the Gulf of Mexico and in Brazil's Campos Basin. Deepwater itself has or perhaps had currency as a description of a category of activities applied to particular locations. Exploration and production activities in the Campos Basin predate those in the Gulf of Mexico. The organisation of activities in the Campos Basin differed from the Gulf of Mexico in that these were organised, licensed and undertaken within the sole organisation of Brazil's national oil company, Petrobras. Until the 1990s, deepwater exploration and production in the Campos Basin was basically a nationalised industry. Despite the technological and geological similarities between deepwater exploration in the Gulf of Mexico and the Campos Basin, the social and economic dimensions differ widely and this provides us with a reason for understanding these as distinct niches. An important consideration for the Brazilian government in undertaking nationalised exploration and production was to secure autonomy in the supply of hydrocarbon reserves, given the context of macroeconomic instability. It just so happened that Brazil's significant hydrocarbon reserves are located in deepwater in the Campos Basin.

The Brazilian government chose to establish Petrobras as the national oil company and recruit individuals internationally to work for it rather than issue exploration licenses to privately-owned trans-national oil companies. This delayed the onset among privately-owned oil companies of understandings that deepwater exploration and production could become an economic resource as there were few spill-overs of information allowing for the development of auditable economic models. The Gulf of Mexico was then the pioneering deepwater location, and as we argue niche, for the privately-owned trans-national oil companies. The distinction between the deepwater activities undertaken in the Campos Basin and the Gulf of Mexico in the 1970s and 1980s also demonstrates that niches have technological, social and economic dimensions as well as those pertaining to the hydrocarbon reserves.

In general terms, oil companies are prospecting for new hydrocarbon reserves continually. If they are to be on-going entities, able to continue using and re-using their capabilities, they must replenish their proven hydrocarbon reserves. Replacement ratios of proven reserves relative to production over given periods of time are significant performance measures for these companies. The larger the company, the larger the discoveries need to be in order to sustain that company. Oil companies first undertook exploration and production offshore on continental shelves during the 1950s (Schempf 2004). A prominent example is the exploration activities in different countries' jurisdictions in the North Sea during the 1960s. Compared with Geels's (2002) explanation, the problem in the socio-technical regime or cluster is not so much one immediately of dissatisfaction with an establish technology, product or means of organisation, but of the perceived lack of opportunities for prospecting. While by the mid-1970s two-dimensional seismic data and speculative geological models suggested that large hydrocarbon reserves existed in deepwater, further technological developments were required in exploration, appraisal and production in order that these could be perceived as potential resources.

By the late-1980s a working definition of deepwater activities had become established as being undertaken in water depths greater than 1,000 feet. This is of course a rule of thumb as the technical difficulties of working in deepwater, such as high pressure and high temperature conditions below the sea bed, cold temperatures on the sea bed and thin overlays do not necessarily correlate with water depths of 1,000 feet. For instance, sea conditions are generally much more turbulent in the relatively shallow water depths of much of the North Sea. Nevertheless, in the Gulf of Mexico the outer continental shelf is distinguished by a steep gradient approximately between 1,000 and 1,500 feet of water depth. Generally, companies are either prospecting for hydrocarbon reserves at water depth of less than 1,000 feet (the inner continental shelf) or greater than 1,500 feet (the outer continental shelf and beyond).

An exception is Shell's Cognac development, which is at a water depth of 1,023 feet. This was announced as a discovery in 1975, with production beginning in 1979. Its significance is mainly through hindsight, with the 1,000 feet working definition becoming established among oil companies and industry journals, and also with Shell becoming the pioneering company in undertaking deepwater exploration and production in the Gulf of Mexico. Exploration and production technology involved a marginal extension of established techniques and of infrastructure. This is more Marshallian, so little to do with the formation of a niche as understood in approaches (2) and (3). If we take the niche and the socio-technical regime or cluster to be synonymous, as with approach (1), then we might consider the Cognac project as a minor adaptation.

The upstream petroleum industry has since its early years been vertically dis-integrated, to include oil companies that specialised in prospecting and in acquiring exploration rights or licenses,

drilling companies and services companies. As the industry has expanded in size, so the distinctive roles in each have become more embedded, with each taking more responsibility for the acquisition and application of technology, if not its development (Finch 2002). Outsourcing as a strategy was being adopted in different degrees across oil companies and was arguably well-adapted to the mature state of the industry in its offshore activities during the 1980s. The outsourcing method of organisation, with its tacit admission that established technologies were fundamentally "fit-for-purpose", was poorly suited to deepwater exploration and production activities.

Not only did companies intending to enter into deepwater not have all the appropriate technologies to hand, but for some but companies their dominant means of organisation, such as out-sourcing, was not conducive to developing appropriate technologies. This is not so much a tension that promoted the development of a deepwater niche in the senses of approaches (2) and (3), but one that emerged alongside the articulations of experiments among those agents (companies) that undertook entry into deepwater activities, especially during the 1980s. The primary tension as experienced by some oil companies during the late-1970s and 1980s was in perceiving that large hydrocarbon reserves, which are essential to these agents' capacities to reproduce themselves, were less likely to be discovered in the established offshore locations.

Initial levels of deepwater exploration and production activities in the Gulf of Mexico were low. Taking 1975 as a starting point (which makes sense retrospectively and given the bench mark of water depths greater than 1,000 feet), there were only 17 projects under production by the end of 1997. This in itself was a marked increase on the six projects under production as of 1992. By December 2003, there were 86 projects under production (Richardson et al., 2004, p. 5). Figure 1 presents this growth in activity in terms of leases acquired and the average depth of the fields under development. Although the trend in lease acquisition (on a three year moving average) varies with business conditions (primarily oil price), the overall number of fields under development has grown substantially. Moreover, as Figure 1 describes, the average depth of field has increased consistently over the years. What has changed is the type of oil company applying for these leases and undertaking field development, as we will assess further in Section 5.

[Figure 1 about here]

The MMS has been as active and experimenting an agent in developing deepwater as a type of prospecting activity in the Gulf of Mexico as those oil companies entering the sector. The MMS's activities may be compared with Kemp et al.'s (1998) argument in favour of government protection in developing niches, but in their case the government is an outsider regulator rather than an experimenting agent. The MMS has to make the Gulf of Mexico seem attractive to at least some oil companies, such that it can earn revenues from the sale of licenses and from taxing the volumes of hydrocarbons produced in its jurisdiction. In the absence of experimentation, it is common to assess the activities as optimising revenues over given time periods through its varying of parameters such as signature bonuses in granting licenses, the length of licenses and its taxation rate on production.

The MMS is one of a number of potential suppliers of exploration and production opportunities. In terms of approach (3), these opportunities are only economic resources if connected with the exploration and production resources, activities and plans of oil companies. In contradiction of approaches (1) and (2), the connections between the MMS and oil companies are interactions if the exchanging of licenses extends beyond simple transactions.

Just as oil companies are learning about the geology of the Gulf of Mexico in deepwater, and developing geological models and exploration and production techniques, so too is the MMS. Richardson et al. (2004) argue that the introduction of the Deepwater Royalty Relief Act in 1996 has had a significant impact on the levels and types of activities being undertaken. The Act divides the Gulf of Mexico into bands by water depth: 200-400 metres (straddling the conventional 1,000 feet definition of deepwater), 400-800 metres and deeper than 800 metres (ultra-deepwater is another conventional term, usually discussed in industry journals as commencing at water depths of 7,000 feet). For exploration leases (licenses) granted between 1996 and 2000, Federal royalty payments are suspended on the initial 17.5 million barrels of oil equivalent (MBOE) for water depths of 200-400 metres, rising to the initial 52.5 MBOE for water depths between 400 and 800 metres, and again to 87.5 MBOE for water depths exceeding 800 metres. In addition, leases have longer dates to expiration the deeper is the water in which particular exploration rights are granted, increasing from six to eight and ten years, respectively.

Given the relative scarcity of drilling rigs capable of exploration in ultra-deepwater, typically owned and operated by separate drilling companies, relative to the large number of exploration licenses granted – notably between 1997 and 1999 – Richardson et al. (2004) predict that many

licenses will expire or will be sold on to other oil companies with only a few years remaining before expiring. Royalty relief has continued since 2000 in a modified form, ranging from the initial 5 MBOE in water depths between 400 and 800 metres to the initial 12 MBOE in water depths beyond 1,600 metres. This reflects the development of deepwater's frontiers in the Gulf of Mexico and the normalising of activities in water depths in and around 1,000 feet.

An appreciation of the MMS's learning through its granting of leases and its observations of oil companies' exploration activities can be inferred from its explanations of rejecting offers of signature leases in granting exploration rights. Hence, 'the rejection trend follows the fact that, as more deepwater fields began production, they provide analogues (with high production rates, thick reservoir sections, and production infrastructure) and thus reduced the risk on similar deepwater blocks, leading to an increase in estimated net present worth of the leased deepwater blocks' (Richardson et al. 2004, p. 37). This reflects a mode of learning among most agents. The means of feedback and interaction is in adjusting and updating geological models, based on analogues. Despite the rapid increase in coverage of three-dimensional seismic data, and by techniques of 'pre-stack depth migration', these lead to hypotheses tempered by analogues developed from data captured through other exploration, appraisal and production activities (Bloch and Voola 2004). Seismic data is available widely (as an abundant resource following Approach (1)) but it is "cleaned" using algorithms developed within companies and assessed along side models in which variables and interactions are accumulated through each companies' experience (following Approach (2)). Finally the MMS acquires data indirectly based on companies' decisions to abandon exploration, or to continue on to appraisal and possibly to production. If production occurs, the MMS metres its volumes.

Shell's Demonstration Project in the Gulf of Mexico

Pioneering projects and events can acquire rhetorical status within communities, such as Geels's (2002) socio-technical regimes or clusters. For this reason, we assess Shell's continued role in developing what we argue is the deepwater niche in the Gulf of Mexico as an industry phenomena. Shell's Auger project, more so than its early Cognac project, acquired this status. It has an average water depth of 2,860 feet, was announced as a discovery in January 1987 and began production in 1994, making it chronologically the 40th deepwater discovery in the Gulf of Mexico and the 11th to commence production. Auger was also the deepest deepwater project to commence production as of 1994. The most apparent innovation with Auger is its production technology in adopting a floating tension leg platform. Auger is also unusual in that Shell owned a one hundred percent stake in the project. Most projects develop shared ownership patterns as they progress through phases of appraisal, sanctioning and production. Usually the company with majority ownership adopts the role of operator.

Shell has a reputation for undertaking research in drilling and offshore technologies (Acha 2002). This is a significant factor in leading to its pioneering role in deepwater. Its role as a leading major oil company also attracts geologists and project managers who seek difficult and uncertain projects as means of developing their professional reputations within the company and also within professional organisations, such as the Society of Petroleum Engineers. In the absence of demonstration projects – and the case of Petrobras was dismissed owing to its nationalised organisation – Shell's senior managers had to decide whether to sanction Auger in conditions of Knightian uncertainty. This was entrepreneurship and experimentation on a large scale. Shell had undertaken out-sourcing to a lesser extent than other majors and had maintained a greater research and development function than some other majors. It had become renowned for operating research and development in drilling.

A certain level of expertise and even arrogance among its middle-managers and technical specialists would have led to the proposal of more complex projects for sanctioning by senior managers. By implication, stimulating and technically complex projects provide an exciting working environment for technical specialists. Not only do oil companies need to find additional reserves to replace production, with larger reserves expected in more challenging geological locations, but employees too often seek to develop their expertise. There are many dimensions to oil companies' attempts at ensuring their survival and success. Shell's ownership stake of one hundred percent cannot only be explained by its desire to capture as much of the knowledge generated by its experimental activities for itself. There is also a distinct sense in which other companies, even leading major oil companies, lacked the levels of technical capabilities and entrepreneurial commitment to communicate effectively with Shell in a partnership during much of the 1980s.

[Figure 2 about here]

[Figure 3 about here]

Deepwater exploration is of course no longer the preserve Shell or of a small group of major oil companies. 'Second tier' oil companies such as Conoco, Kerr-McGee and Amerada Hess have entered and by the late 1990s smaller independent companies (companies that are not vertically integrated into downstream activities) had entered too (see Figures 2 and 3, above). Some were undertaking complex projects in ultra-deepwater. One caveat remains. There is typically a seven to ten-year gestation period between discoveries being announced by oil companies and then production taking place. Production is the preserve of large major oil companies, such as Shell, BP and Exxon-Mobil. There are significant technical problems faced in production, separate from exploration, often to do with extending the reach of subsurface production facilities across satellite projects. Ultra-deepwater has a lower density of production infrastructure, such that means of tying back new developments into the facilities of established projects are still experimental and subject to research and development.

Temporality and the Niche's Bounds

In this section we have sought to identify the bounds of the niche. There has been an intensification of deepwater exploration activity since 1975, and most notably during the period of the Deepwater Royalty relief Act, and some extensification in exploration in ultra-deepwater. Shell was the pioneering major oil company in exploration and production. It still has the most experience in deepwater production, but has been overtaken by BP as the company with the largest proven deepwater reserves. Independent oil companies have acquired significant acreage in terms of exploration licenses. These include ultra-deepwater projects. There is a tendency for companies to take shares in the projects of comparable oil companies and in most cases these are motivated by sharing risk rather than sharing technology. While production is problematic, and shareholding often focuses in project development and production, it is less important in securing the survival of agents (companies, business units) than making significant discoveries of proven reserves.

Agents are included in the perspective of the niche on the criteria of having comparable and significant contacts with entrants and established agents. For instance, all agents have to establish relations with the MMS in order to acquire the status of operator. Further, the MMS also has a monopoly in supplying licenses for exploration and production activities. Until the Deepwater Royalty Relief Act, the realised niche was less extensive and intensive than the spatial jurisdiction of the MMS. But the Deepwater Royalty Relief Act accelerated the pace at which exploration licenses were taken up, leaving many agents with the perception that any significant reserves were already under license. This has encouraged both the extensification of deepwater activities in the Gulf of Mexico, and also the spill-over of the deepwater niche to other jurisdictions, significantly along the West Coast of Africa. Given that the MMS is now confident in its understanding of likely reserves and also of the nature of exploration and production technology available to many companies, it is in a position to undertake pricing decisions that are tilted towards optimisation and away from experimentation. These are all indications that deepwater activities in the Gulf of Mexico are no longer taking place within and so contributing towards a niche.

Shell can be included as an agent with influence and connection across the niche itself for a period of the niche's development on account of its Auger project acquiring the status of a demonstration project. Further, the project has this status in real time, as opposed to its Cognac project, which acquires its status retrospectively. The combination of Shell being a company both owned privately and quoted publicly and its need to acquire licenses from the MMS requires public disclosure of its activities. This also meant that watching companies could infer that deepwater exploration and production could be an economic activity. Auger is an example of Shell and watching companies all undertaking 'learning from samples of one or fewer' (March et al. 1990). These opportunities were less likely from observing the activities of Petrobras in Brazil's Campos Basin owing to the nationalised organisation of these activities in its pioneering phase.

Finally, we address Geels's (2002) model of the emergence of a niche or niches from an established socio-technical regime (or cluster) and its eventual re-entry as a selected technological transition of that regime (or cluster). Although Geels's appreciative theorising is connected with an historical case study, the connection between the case and the theorising is not especially temporal in identifying bounds. Deepwater methodologies are derived from offshore exploration and production activities in challenging locations, especially as these were being undertaken in the Norwegian and UK sectors of the North Sea in the 1970s and 1980s. But the niche emerged through agents recognising

that gradual adaptation of established technology was feasible only in a subset of the new problems posed by undertaken deepwater activities.[3] It is only in undertaking experimental activities given entrepreneurial plans in the new setting, and realising that established solutions are not all adaptable that the new setting acquires the status of niche can support niche practices. We delay discussion of the re-entry of what were niche practices as selections in the form of technological transitions until the next section.

The Intermingling of Resources, Activities and Agents within the Gulf of Mexico's Deepwater Niche

As argued in Section 3 (above), we have selected a sample of five companies aside from Shell (see Section 4, above) that have over particular phases contributed to the development of the niche. We are seeking to explain each company's role in the development of the niche over a particular phase and also explain the development of that company through its involvement in deepwater exploration and production in the Gulf of Mexico. BP was behind Shell and Exxon in entering deepwater, or at least in announcing discoveries from its exploration activities. It now has the largest proven deepwater reserves in the Gulf of Mexico and is embarking upon production activities. Conoco demands further investigation because it was a pioneer in deepwater despite not being a major oil company. We also draw upon the case of ARCO, which prior to merging with BP in 1999 was conspicuous as a second-tier integrated oil company undertaking deepwater activities. We include Statoil as arguably it is conspicuous by its absence from undertaking deepwater exploration and production in the Gulf of Mexico despite possessing appropriate technical capabilities. We include Woodside as it is a late entrant into deepwater in the Gulf of Mexico, allowing us to assess whether its entry demonstrates that it is no longer a niche.

One feature of a niche and its agents' practices is that these defy dualistic characterisations of as competitive or collaborative, or vertical or horizontal (Maskell 2001, Araujo et al. 2003). The established pattern in the upstream industry of relations and exchanges for oil companies among services and drilling companies has become replicated for deepwater exploration activities in the Gulf of Mexico, and to a lesser extent for production activities. Håkansson and Waluszewski's (2002) four categories of resources (products, facilities, relationships and business units) necessarily have the capacity to interact autonomously and be interacted deliberately as agents undertake activities. The re-use of relationships and means of organisation (relationships and business units considered as resources rather than agents) established for offshore activities has been difficult because adaptations of these have been constrained by many established technologies (facilities and products as resources) being unsuitable for deepwater.

The four categories of resources are usually applied to situations in which business units can by identified with separate companies with dis-similar capabilities (Richardson 1972). Deepwater as a niche has less clear boundaries around resources and our five companies occasionally collaborate but are not organised into upstream and downstream roles or vertical relationships. The categorisation is still useful as a basis for comparing our five cases. We can articulate a research proposition that niches are situations in which resources come to be defined (and acquire functions) through the activities and interactions of agents.

BP

BP has taken over from Shell as the most successful prospector in the deepwater Gulf of Mexico. It has the largest proven hydrocarbon reserves and a smaller proportion of these have progressed to production projects as compared with Shell. For much of the 1980s, BP seemed to be pursuing a strategy of "watching brief"` by acquiring minority stakes in three projects discovered and operated by Shell and also by Exxon. The idea of "watching brief" is an example of the intensification of relationships in an element of exploration and production which neither company would consider as critical in developing exploration know-how, but would be essential in reducing the risks associated with committing further funds to exploration. As an exchange, Shell reduces its exposure on a particular project by selling a minority share to BP. Developing an exploration project into a production project is still an uncertain business, particularly in the mid-1980s in deepwater in the Gulf of Mexico. BP learns something of planning to develop a discovery into a production project, although exchanges

[3] "In other words, everything about Thunder Horse [BP's flagship deepwater project in the US Gulf of Mexico] is at or beyond the limits of the offshore industry's experience. And that means that tried and tested off-the-shelf solutions that have served the industry well over time, are few and far between when it comes to meeting Thunder Horse's inherently difficult operational demands." (Knott, 2004a, p. 7)

of information are bounded. More importantly, BP gets to improve its replacement ratio in connection with significant hydrocarbon discoveries and at lower risk than by undertaking its own deepwater exploration projects, which is a motivation not relating to a niche.[4] Both companies exchange inputs and so contribute to each others' survival.

Both Shell and BP undertook their deepwater exploration and latterly production activities within deepwater business units specific to the Gulf of Mexico. This organisational form reflects the difficulties faced among senior managers within pioneering deepwater companies in providing some protection to deepwater activities and at the same time providing accountability to shareholders in undertaking activities of a different character. It was difficult to compare projects proposed within deepwater with more established projects. Pioneering deepwater projects would have to create much of the data that are often taken for granted in appraisals of other projects. Rather than governments providing protection by establishing or guaranteeing niches (Kemp et al. 1998), deepwater business units were organisational forms protected within trans-national corporations. The expected quid-pro-quo though between the unit and the senior managers is much clearer than would be the case if protection is through state intervention. Deepwater activities have to provide large discoveries of hydrocarbons for the overall corporation in order to improve its replacement ratio. It also has to provide enhanced techniques in seismic analysis, forming and appraising geological models, drilling techniques, production methods and facilities development that can be re-used elsewhere and provide its staff with prestigious careers.

BP's subsequent successes in the mid and late1990s, notably in the discoveries of the Thunder Horse and Thunder Horse North reserves, can be associated with the activities of a "heroic" geologist who had been attracted by the prospect of working in deepwater. They had benefited from the formation of a business unit within the company to specialise in deepwater exploration. The novel (entrepreneurial and experimental) activities of geologists involve developing modelling techniques, which are essentially algorithms for cleaning seismic data in the face of accumulations of salt and drawing inferences from their modelling activities. The business unit as a resource is one part of this success. Another is in developing geological models and algorithms as specialised facilities, with the key characteristic of a facility being its re-use (Langlois 1999). We infer that geological became facilities used within business units by observing the cluster of successful discoveries over a particular period of time for BP. Through undertaking deepwater exploration and production as an entrepreneurial experiment, BP and Shell were both able to develop resources within their own trans-national organisations, as the deepwater business units and initially as geological modelling facilities.

BP managers now see themselves as bound inevitably to deepwater activities into the medium term, predicting that by 2016 half of its projects are expected to be in deepwater, with a significant proportion in ultra-deepwater (Knott 2004b). BP maintains a majority shareholding in its projects, typically of between two-thirds and three-quarters and still holds minority interests in the projects of other oil companies. BP, Shell and Exxon regularly hold shares in each others' projects and the dominant pattern is of three or four partners only.

The emphasis in solving problems for BP in its deepwater activities has shifted from exploration to production. This is an example of how deepwater imposes different decision-analysis demands upon its senior managers and those proposing projects. Estimating costs of a deepwater project's lifetime as of the mid-1980s and even mid-1990s would have been much more difficult than in the case of other projects as exploration was undertaken ahead of the development of production technologies and facilities. BP sees its research and development activities in relation to deepwater production as to 'identify the breakthrough technologies that will keep costs down and convert these into practical and reliable solutions for BP's business units' (Knott 2004b, p. 1). This is an acknowledgement that significant technologies are developed within BP or in partnership between a services company and BP, but as a product to be used with BP with the intention that it becomes a facility for BP especially in production.

A further implication is that BP will generate sufficient numbers of projects in deepwater through its continuing exploration activities that economies can be reaped internally in re-use over time. Further, the presence of these production facilities will change the cost-benefit profile of proposed projects. A current example is in developing the capacity to tie-back satellite developments into established ones (as hubs), where satellite developments are up to 35 kilometres from the hub. A new technology and facility is required in order that an established one may be used more intensively. This facility has to be automated to a high degree given the difficulty of interventions in deepwater,

[4] There is an appreciation of something like Knight's (1921) distinction between stochastic risk and radical uncertainty among agents in the industry (Macmillan 2001, Finch et al. 2002). Agents also tend to understand risk as being a worst case scenario or a best estimate of the funds being put at stake in order to realise a proposed project.

and cope with hydrocarbons emerging from high-pressure and high temperature conditions under the sea bed and through low temperatures on the sea bed.

Conoco

Conoco is an integrated oil company and has maintained its relative (second-tier) position among other oil companies through its recent merger with Phillips Petroleum. It is not considered to be a major or super-major oil company. It is perhaps surprising to note that Conoco was a pioneer in undertaking deepwater activities in the Gulf of Mexico, in contrast with the "watching briefs" of BP and Exxon during the 1980s. Conoco announced the discovery of the Joilett field in 1980 and began production as operator in 1989 with Chevron being a significant minority shareholder. It had minority shareholdings in three other projects during the 1980s but sold these. It has also been a shareholder in two of Shell's larger deepwater projects in the Gulf of Mexico.

Conoco is part of a trend among those oil companies entering into deepwater of having accumulated experience in the Norwegian and UK sectors of the North Sea during the 1970s and 1980s. The North Sea was considered widely to be a mature province as of the late 1990s. During the 1970s it presented oil companies with large discoveries and difficulties in coping with volatile subsea conditions in relatively shallow water (Schempf 2004). Conoco's main contribution to deepwater is in adapting its tension leg production platforms (TLPs) and associated technologies (Conoco 1997, p. 7). Basically TLPs are floating production facilities moored to the seabed. Fixed facilities cannot be used in water depths of over 1,000 feet and the MMS will not license floating production and storage and off-loading (FPSO) facilities in the Gulf of Mexico, citing safety and environmental reasons. Conoco developed and patented its TLP technology while undertaking production at its Hutton project in the UK's North Sea from 1983. Its main advantage in the North Sea is overcoming turbulent sea conditions.

Conoco was able to offer technologies and experience in use pertaining to its TLP facility to itself and to other oil companies entering deepwater as pioneers. This places it in an unusual position as an oil company alongside the majors such as Shell, BP and Exxon, but also potentially as a supplier of a significant production facility. This dual role of Conoco requires careful consideration. TLP and experience in using it provided Conoco with a significant bargaining position to acquire minority interests in the projects of majors, such as its 16 percent holdings in two large projects discovered and operated by Shell. These began production in 1999 using TLPs. In addition, Conoco operates the Magnolia project in the Gulf of Mexico. The Joilett project ran into technical difficulties upon production. Deepwater production was still an experimental activity. Conoco then withdrew from Deepwater exploration at the time that it was being spun-off from its former parent company, Du Pont. Being owned by Du Pont contributed to Conoco being a pioneering deepwater company in the first instance. Conoco has subsequently acquired significant exploration licenses from the MMS under the Deep Water Royalty Relief Act and has also bought two drill-ships in order to undertake exploration in anticipation of their being significant shortages in rentable drillships with the capacity to undertake exploration activities in ultra-deepwater.

The one conclusion to be drawn from Conoco's pioneering entry into deepwater, its withdrawal and then re-entry is that the size of the business unit matters. Owning the TLP facility considered as a product allowed it to acquire minority shares in significant projects and this addressed the corporate problem of restoring and improving the reserves replacement ratio. But in terms of the niche, minority ownership provides few opportunities to acquire capabilities in articulating and appraising experimental projects. Majors can exchange minority interests in each other's experimental projects in order to reduce perceived risk in undertaking existing and further projects. In niche terms, they undertake their own exploration activities, then exchange shares in developing discoveries into production projects.

Statoil

Using proven worldwide hydrocarbon reserves as a measure, Statoil is about two-thirds of the size of Conoco, and Conoco is about two-fifths the size of BP. Statoil is owned in part by the Norwegian government after an initial public offering in 2001. We have argued so far that Shell, BP and Conoco were able to draw on their experiences gained in the Norwegian and UK sectors of the North Sea while undertaking pioneering exploration activities in deepwater in the Gulf of Mexico. Conoco additionally adapted its TLP technology in undertaking subsequent production activities. Statoil has with Shell been undertaking a large gas project (Orman Lange) in deepwater in the Norwegian North Sea, which it discovered in 1997. Our surprise is that Statoil, despite being as well prepared as

Conoco to undertake deepwater exploration, has had one brief spell of exploration activity in the Gulf of Mexico through buying into other projects and then selling on these shares during the late 1990s.

Two arguments can be offered in explaining Statoil's behaviour. First, the Norwegian government's involvement could provide a ranking of projects and even of experiments in undertaking exploration prior to projects being proposed, which take into account Norway's long term macroeconomic planning. The pressures of improving reserves to production ratios differ as Norway has hydrocarbon reserves, as does the time preference. Second, Statoil would have been seeking new projects after its initial public offering at just the time when the Deepwater Royalty Relief Act was coming to the end of its first phase. As pointed out in Section 4 (above), it was around this time that the MMS considered itself to be in command of sufficient information to start judging bids for exploitation license as too low. The price of licenses in the Gulf of Mexico could have been perceived as being too high. Instead, Statoil has taken minority ownerships in deepwater projects in Angola and in Nigeria, where it took part in strategic alliance with BP from 1993 to 1999.

The significance of Statoil's case for our argument is that it lends support to the proposition that niches end when they become locations for normal activities. An indication of normality is in the MMS's ability to judge whether bids are in its interests. Further, Statoil remains an attractive minority partner to some majors in other deepwater locations. This is partly on account of its established technical competence derived from the Norwegian industry. Establishing a relationship with Statoil can be seen as a resource despite Statoil's relatively small size and its historical development as a company owned by government and operating in the unique Norwegian socio-technical regime.

ARCO

ARCO was also a second-tier integrated oil company and was acquired by BP in 1999. We are relying on a retrospective analysis (drawn mainly from interviews undertaken just before BP's acquisition) of how ARCO entered deepwater and of its means of coping with undertaking necessarily experimental activities, given the time period under consideration. We are as surprised with ARCO's early entry into deepwater as we are by that of Conoco. ARCO entered on its own through acquiring exploration licenses and undertaking exploration activities in the early 1980s and so can be compared with Shell's early means of entering deepwater.

Our interviews with ARCO managers just prior to BP's takeover suggest that initially deepwater was considered to be an adaptation of established offshore exploration and production. Exploration and production could be undertaken on the basis of accumulated internal experience together with that available among services companies. Adaptation could be undertaken as interactions within a given structure of resources. ARCO's learning-by-doing was though more limited than that of Shell, BP and Conoco (and for that matter Statoil) on account of its smaller size and lack of experience in the Norwegian and UK sectors of the North Sea. ARCO faced greater constraints upon developing projects beyond exploration and in being able to take minority positions in other companies' projects, even if for risk management reasons rather than in gaining knowledge through experiment. ARCO "gave-up" in 1989 after three exploration projects failed to provide evidence of proven hydrocarbon reserves.

ARCO re-entered deepwater in the Gulf of Mexico in 1996, thereby establishing a pattern of exit and re-entry similar to Conoco's only doing so earlier. ARCO's re-entry coincides with the beginning of the Deepwater Royalty Relief Act. Its means of entry was distinctive. Internally, ARCO established a business unit dedicated to deepwater exploration and production (in particular, international deepwater). Externally, ARCO established a subsidiary company (owning 82.3 percent), Vastar Resources, to undertake new exploration and production activities in the Continental Lower 48, including deepwater Gulf of Mexico. In order to "catch up" with the technologies and methodologies used in deepwater without paying the full price, ARCO joined the leading joint industry deepwater programme, Deep Star, and sought to play a leadership role within the Programme to capture benefits most effectively. Texaco had launched Deep Star in 1992 for similar reasons. Texaco was a relatively late entrant, especially given its status as a major, and also lacked the critical accumulation of exploration and production experience in the Norwegian and UK sectors of the North Sea during the 1970s and 1980s. The deepwater group at ARCO included in its remit the identification of new technologies required for production. Exploration was seen as less problematic, or at least fairly impervious to any expected technological developments emerging specifically within deepwater activities. From being self-acknowledged laggards in deepwater, two projects were announced in 1999. Both – King and Horn Mountain – are now significant projects among BP's proven reserves.

In terms of resources, ARCO had to establish two organisational solutions in order to enter deepwater. Internally, the deepwater business unit was a similar niche to those established in Shell

and BP. But it needed an external organisation as well as it generated too few deepwater projects and had too little accumulated production experience offshore to depend only on this internal organisation. ARCO needed to develop absorptive capacity and relationships with other companies' business units rather than adapt some established practices worked out in other relatively challenging offshore locations.

Woodside

Woodside is a recent entrant into deepwater activities, including in the Gulf of Mexico. It has experience in undertaking exploration and project development in deepwater in Australia (including the Enfield project off Western Australia, in 600 metres of water, of which it owns 100 percent). Woodside has benefited technologically, in developing organisational procedures and in developing further its capabilities in seismic analysis and geological modelling through is relationship with Shell. Shell owns 38 percent of Woodside. Woodside, in a manner similar to Statoil, has made a strategic decision to develop interests internationally. Its first deepwater project has been in Mauritania, originally in partnership with Agip of Italy, with production due to be commencing in 2006 subject to project sanctioning (Woodside 2004). It is symptomatic of the maturity of deepwater activities, especially in the availability of technologies from services companies and drilling companies that Woodside has not established a deepwater group in the way that ARCO (a much larger company) did in the mid-1990s. Further, Woodside has decision-analysis procedures that have been applied to on-shore and deepwater projects as well as more conventional offshore developments. In the Gulf of Mexico, Woodside has acquired a 20 percent interests in the Neptune field, operated by BHP-Billiton. Again, the project is in development and appraisal. During 2003, Woodside increased its lease holdings in the Gulf of Mexico for 79 to 129 leases, although not all of these are in deepwater.

Interactions of Resources Where Horizontal Differentiation is Significant

In the more mature socio-technical regime or cluster of the international upstream petroleum industry, vertical disintegration, procurement and managing supply chains or networks is the norm (Richardson 1975, Langlois 1992). But a characteristic of deepwater as a niche from the perspective of oil companies is one of vertical integration. Part of the process of deepwater acquiring niche status is in many of its early entrants establishing reflecting this niche in their own means of organising through establishing deepwater groups.

One means of explaining the reflection of the niche as distinct from the socio-technical regime or cluster as a business unit within the oil companies is environmental contingency; of responding to a threat. This argument is not sensitive to the details of timing. Deepwater is not "out there" requiring further investigation, but rather is investigated through being brought within, partly in the form of a business unit. Deepwater business units are from the corporate perspective an organisational experiment. From within the unit itself, it is a means of organising an experiment and especially of acquiring funds and a means of accountability for those funds in manner distinct from means for funding established exploration and production projects.

In terms of Håkansson and Waluszewski's (2002) four categories of resources (products, facilities, relationships and business units), we depart from the Richardson etymology (Richardson 1972). Instead, the resources (or capabilities) are defined from the perspectives of companies as being mostly internal to companies initially. This makes the categories no less valid as there is no requirement for us to understand corporate boundaries as solutions to organizing experiments per se (Alchian and Demsetz 1972, Granovetter 1985). A general type of business unit is then a deepwater business unit, or an experiment to do with the niche, and so a further manifestation of the niche.

The relationships are partly with other organisations, for instance with the MMS, through the joint industry projects such as Deep Star, and through buying share in other companies' projects. But other significant relationships are within companies, including with research and development business units and with senior management groups with responsibility for allocating investment funds. Relationships with other oil companies in the case of deepwater considered as a niche were rarely established and undertaken with the intention of developing know-how. Rather, the acquisition of minority shares allowed for portfolios to be formed allowing risks of particular projects to be dispersed. This had an indirect affect on developing know-how through allowing pioneering companies to undertake additional deepwater activities.

A further connection that was critical – either in being present or absent – was in deepwater entrants also being involved in offshore activities in the Norwegian and UK sectors of the North Sea. To some extent, this was a comparable niche in the late 1960s and early 1970s. We can begin with

the arguments of Penrose (1959) and Nelson and Winter (1982) that resources are accumulations of past activities, and that routines are memory stores. The difficulty is that such processes are usually explained as being autonomous, or shaped by established organizing practices. We know that deepwater business units were experiments in organizing partly as a manifestation of deliberative planning (Loasby 2002). The problem is one of articulating and capturing accumulated experience so that it can be characterised by agents as a (necessarily durable and so objective) resource. Geels's (2002) vision of the niche being a testing ground for new technologies that has to be free from the established practices is too severe. The niche has to be a location for the selection (in general, including deliberation over rejection too) of some established and continuing practices in the form facilities or products (both types of resources) that can be adapted to experimental practices. Examples include procedures for assessing project proposals, analogues for geological models, parameters for geological models and algorithms for cleaning seismic data. We also saw in the case of Conoco's TLP technology that some production facilities can be adapted from turbulent shallow water to deepwater.

Concluding Remarks

In Section 3 (above) we raised the question of generalisation as part of our research process. Given that our research process is qualitative and involves comparisons of cases in relation to some disparate established approaches, which are conceptual and appreciative, we cannot refer to any clear procedures for generalisation. Nevertheless, we make the following claims about generalisation, which are in keeping with our research process and the nature of theories and concepts which we draw upon. First, we have adopted a sampling strategy, akin to theoretical sampling in grounded theory, to capture surprising and significant cases over particular phases in the development of what deepwater exploration and production activities in the Gulf of Mexico. Second, we have articulated general research propositions along with subsidiary questions as means to analyse the processes and tendencies that affect a niche's bounds within phases and temporally, and also the niche's composition in terms of its resources. Third, we identify three established understandings of niches, align our study with these, and compare our findings with Geels's (2002) general explanation of the emergence and dissipation of niches.

The boundaries and resources of a niche interact over time. Considering these as distinct dimensions is a matter of analytical expediency. The boundaries of the deepwater niche in the Gulf of Mexico are in significant part the story of the MMS as an agent in supplying the resources of exploration and production licenses and also of operator status to oil companies. We described the MMS as a macro-agent within the niche on account of its necessary and comparable connections with all participating oil companies. To begin with the boundaries of the niche were determined by the technical capabilities of oil companies and by the willingness of oil companies to entertain entrepreneurial plans for entering into deepwater. That Shell's Auger project attained the status of a demonstration project is significant alongside the Deepwater Royalty Relief Act in attracting other companies to enter. While technically the Campos Basin provided similar deepwater conditions, its nationalised status reduced communications between agents there and in the Gulf of Mexico.

The MMS has lost monopoly power in the supply of deepwater exploration opportunities through the entry of other licensing authorities into deepwater, notably among West African governments. Signifiers of the dissipation of the niche are in the MMS's confidence in pricing its licenses accurately or optimally, and in other agents' abilities to transfer their geological models to other locations, and integrate deepwater into their decision-analysis procedures alongside other projects. The surprising aspect of its dissipation is that there are still problems requiring novel technical solutions. There is still a demand for joint industry projects for developing new production technology. Another signifier of the niche's dissipation is in its ability to support confidence among agents that technical problems can be solved, which is reminiscent of socio-technical regimes or clusters. Production is a shared and social activity. Finding large reserves through exploration activities is the preserve of heroic geologists working within business units within companies.

We were also surprised, with reference to the niche's composition, by the extent to which different types of resources were being organized within companies rather than between companies, especially as exploration activities dominated. This supports our Approach (2) to niches. The critical ability for companies is in forming business units that are capable of replicating the broader niche and having the characteristics of an experimental organisation. Further, these deepwater business units needed means of forming resources as facilities from experience in other locations and then adapting these to deepwater. Approach (2) is tractable though, especially among pioneering companies, if we question the status and function of company boundaries to a greater extent than is customary among

resource-based researchers (Araujo et al. 2003). The advantages of combining business units and in constructing facilities from experience within one corporate organisation, such as in geological models and decision-analysis techniques, are in coordination given an entrepreneurial plan, tolerance to experimental activities, and placing bounds upon experimental activities (Flaherty 2000).

Relationships between agents and between the resources associated wit their activities are never absent and become more prominent as the deepwater activities consider production in more detail. Approach (3) cannot be ignored. It affects how we view approach (2) and exerts an independent influence on our understanding of relationships between oil companies. Even in exploration, relationships are apparent between oil companies and the regulator, and these too survive the transition to deepwater. Where major operating companies take shares in each other's projects, this too signifies that there are relationships. These may appear at first to be "horizontal" rather than "vertical" in the sense of a flow of production activities within the upstream industry covering up and downstream with the sector. The MMS's licenses and granting of operator status are clearly upstream within the upstream sector.

The relationships between oil companies cannot be contained within the horizontal description, even if the connections rarely provide inputs based on specialised knowledge. This happened for instance in the case of Conoco's TLP technology. Even the sharing of risk as hydrocarbon discoveries are formulated into development projects and then sanctioned as production projects provides opportunities for oil companies to undertake further exploration, so can be considered as an input as well as a manifestation of horizontal relations. No doubt some information useful to minority shareholders spills-over in the manner of a cluster too. Penrosian economies of size assist in the capture of economies of growth. We have indirect evidence of this in terms of how companies guard their geological models and their algorithms for cleaning seismic data. Shielding information and knowledge is as much an act of communication as is disclosing it. 'Buffering and bridging' are simultaneous ambitions (Thompson 1967, p. 22).

Approach (3) presumes a process of vertical dis-integration (Richardson 1975, Langlois 1992, 2002). Services companies become involved in developing production facilities and products for and with oil companies in close working relationships and also through joint industry projectors such as Deep Star. In this sense, approach (3) is either a precursor to approach (1) as phases in the niche's development in which each has greater empirical tractability, or a rival to it irrespective of temporality. That ARCO had great difficulty in entering into deepwater first time around, and that Woodside have attempted to enter without the need of establishing a deepwater business unit are indications of this change in the niche, or its normalisation within a more durable socio-technical regime or cluster.

Geels (2002) addresses a similar point in proposing generally that niches provide variants of proto-technical transitions from which agents within – or representing – a socio-technical regime may select among. Where in Approach (1), the strategies such a niche width are readily available within the socio-technical regime or cluster in the form of open code, in approach (3), the technological transitions remain embedded as interactions between resources, revealed through agents' activities and requiring absorptive capacity. We favour the template of an explanation provided by Approach (3) in this explanation that generally foresees the last days of the niche. While Geels' model is a general knowledge claim, it is developed in the context of a longitudinal study of shipbuilding. Our understanding based on the deepwater activities within the upstream petroleum industry is different in that that socio-technical regime is not as durable so provides a less stable basis as a means of selection. Geels has one tendency, of technical outcomes form the niche being re-integrated into the socio-technical regime or cluster. There is another tendency, of the niche being the basis of another socio-technical regime or cluster with technical solutions being specific to the new problems that it identifies as agents establish entrepreneurial plans and realise these through experimental activities.

Facilities developed by oil companies and latterly by services companies have worked there way back to the now more mature sectors of the upstream oil and gas industry, for instant in water depths of less than 1,000 feet in the Gulf of Mexico and in the North Sea. One of the reasons for major oil companies like Shell and BP undertaking deepwater exploration and production was the lack of opportunities in these now mature sectors to provide reserves of sufficient size to enhance their ratios of production to reserves and to sustain their resources and capabilities. There are fewer opportunities for majors involved in deepwater to re-use these techniques in mature activities. To some extent major oil companies are now established to undertake activities in other niches. Their means of organizing is ahead of the opportunities formulated as niches by the supplier of opportunities to experiment, such as the MMS.

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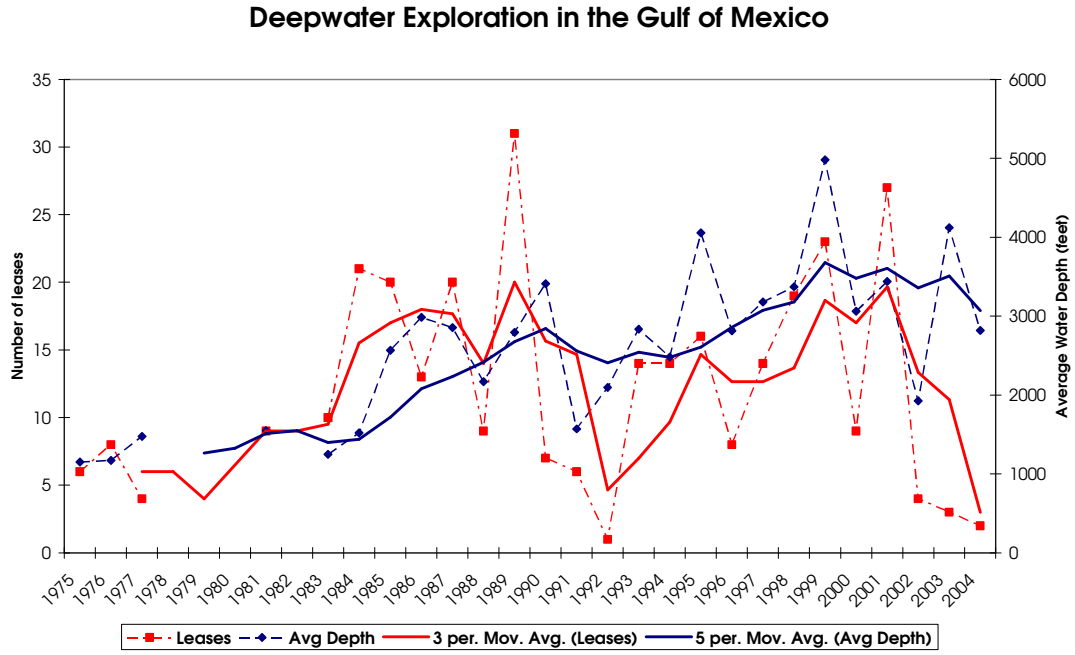
Table 1 Three Approaches to Niches

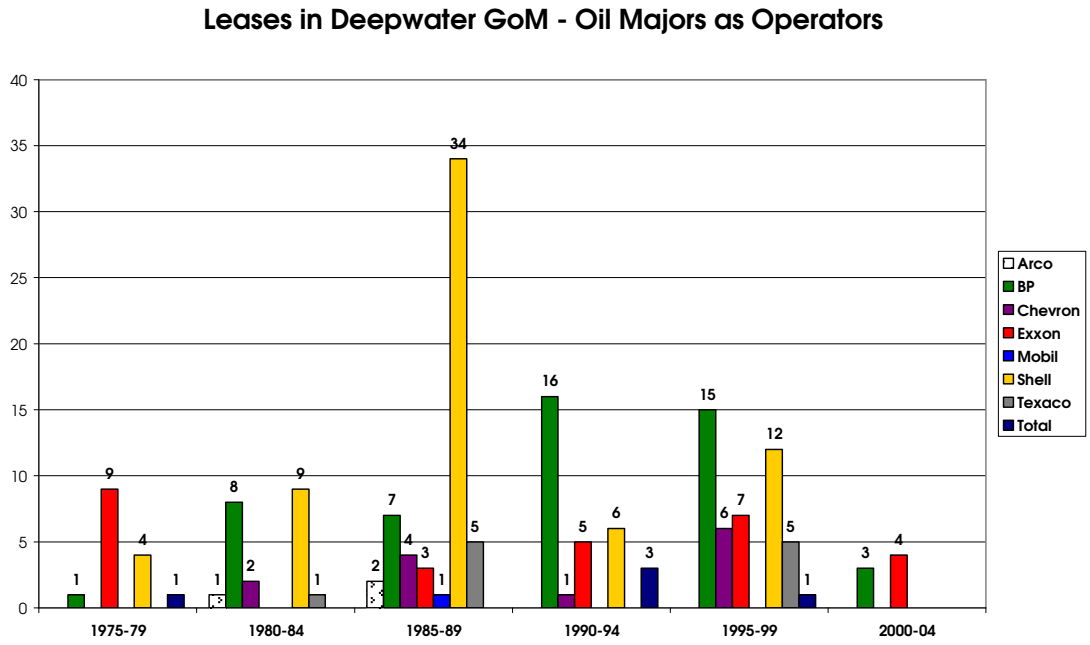
1	***The wellspring***	Niche as a stable ecology, where resources are exogenously defined
2	***The firm's forte***	Niche as a specific location created by a company in its use of resources
3	***Emergence through collective discovery***	Niche as a site of novelty through interacting resources across different agents

Figure 1



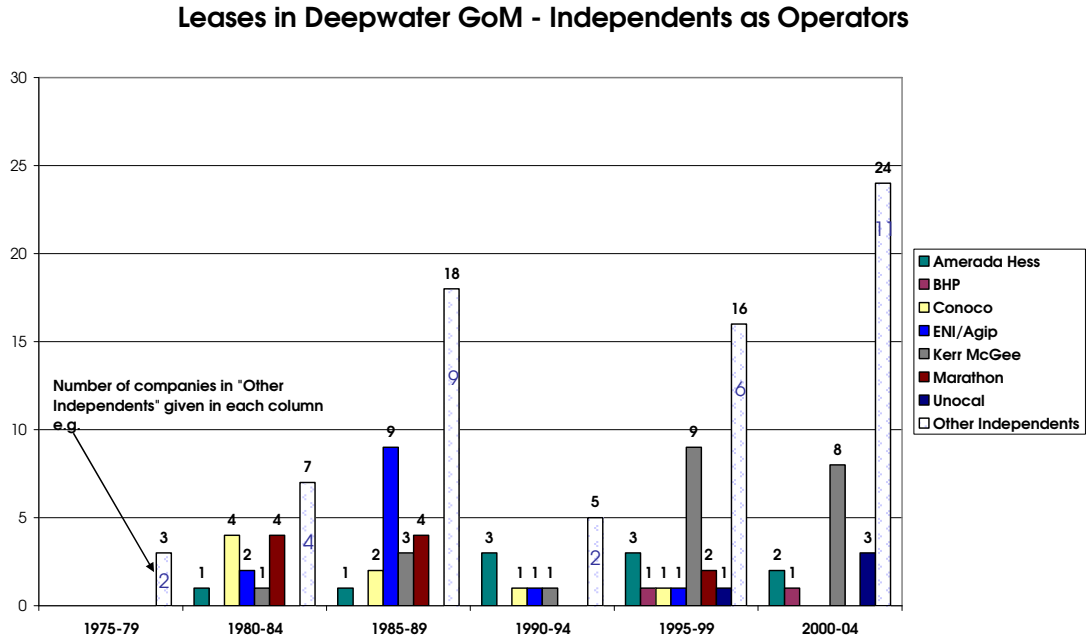
Note: Data from the MMS lease data set for the Gulf of Mexico.

Figure 2



Note : Data drawn from the MMS leases database.

Figure 3



Note: Data drawn from the MMS leases database