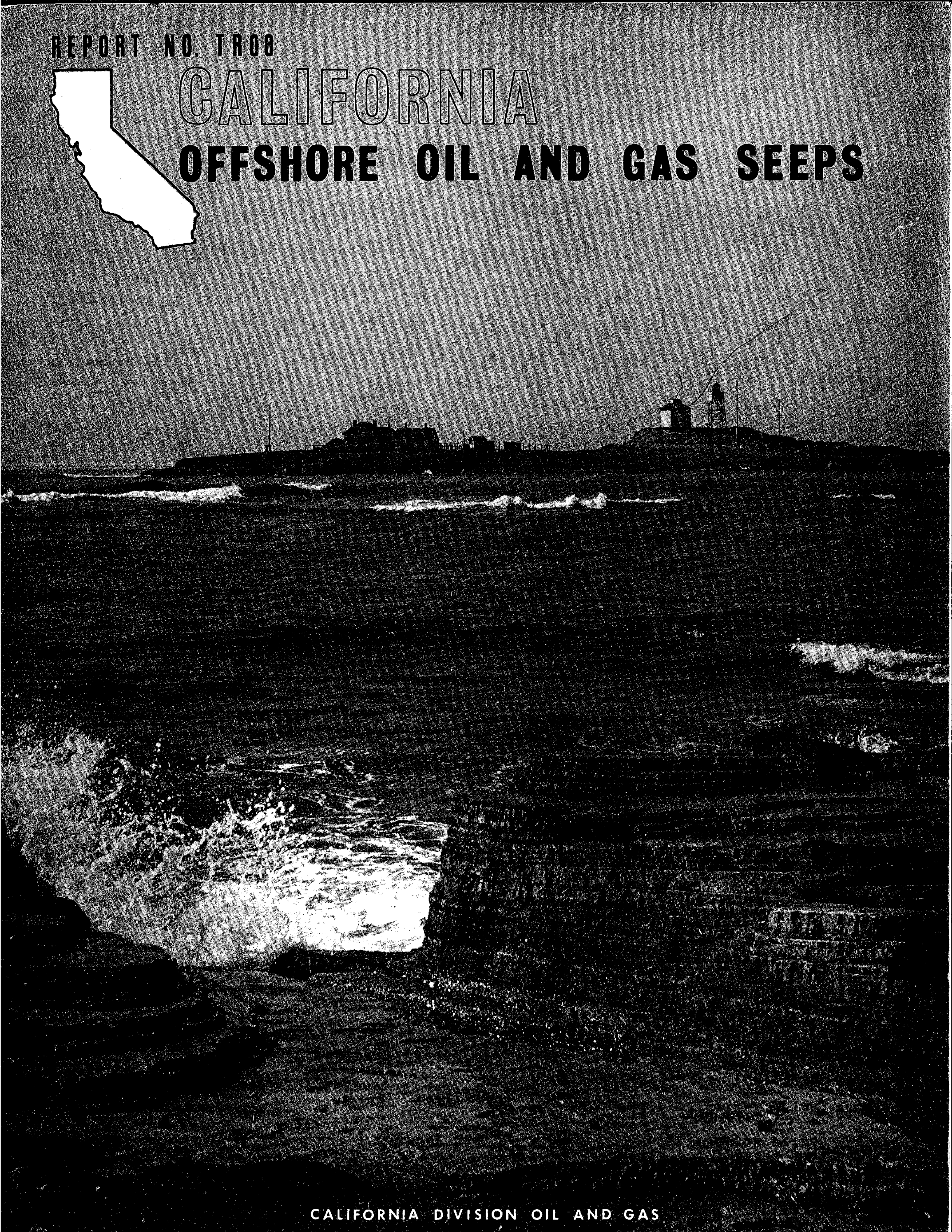
REPORT NO. TR08

CALIFORNIA OFFSHORE OIL AND GAS SEEPS



CALIFORNIA DIVISION OIL AND GAS

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Cover photo by Dick Thompson, Dept. of Parks and Recreation

ERRATA
Division of Oil, Gas, and Geothermal Resources
California Offshore Oil and Gas Seeps

Plate I

Change Seep No. 1 at Platform Heidi (off Rincon Point) in Santa Barbara Channel to seep No. 54.

CALIFORNIA
OFFSHORE OIL AND GAS SEEPS

By Elbert R. Wilkinson [b]

Oil and gas seeps are known to occur throughout the world and have been cataloged and documented by many observers; however, nearly all of the seeps noted were found on land, whereas relatively few references to underwater seeps appear in the literature.

The presence of onshore oil seeps in California, particularly Southern California, is not uncommon. Archeologists have established the fact that prehistoric Indians used tar from seeps to waterproof baskets and calk canoes at least 7,000 years ago. Pleistocene fossils recovered from the La Brea Tar Pits in Los Angeles prove that this famous seep has been in existence for more than one million years, and on warm days other seeps can be seen oozing tar or heavy oil throughout many areas of Southern California.

Considering the presence of numerous active seeps onshore, it is not unusual to find oil and gas seeps offshore; but until comparatively recent times, it appears that relatively little interest was shown in California offshore oil and gas seeps.

All of the active seeps that are known to occur offshore have been found between Point Conception, in Santa Barbara County, and Huntington Beach in Orange County. (Table 1) However, the largest concentration of seeps appears to be in the Santa Barbara Channel area, which is the seaward extension of the oil-rich Ventura basin. The remaining documented seeps are more closely related to the Los Angeles basin than any other geological province.

The possibility that seeps may have existed farther south than at present is supported to some extent by an article which appeared in the trade journal, Oil Age (1923), describing geological structures in San Diego County and the northern provinces of Baja California. The article states that the main geological structures "run out into the ocean ... here they appear to be denuded in places. At times of violent storms ... sands are washed off and oil spills out. On the day after a storm the rocks may be seen covered with fresh oil ... that the oil is not from ships ... is proved by the fact it was noticed before the time of oil burning ships." However, Scripps Institution of Oceanography (1913-1914) stated that they had "seen no signs of it, *(i.e., petroleum)* south of Redondo", and that their exploration of most of the continental shelf off the San Diego coast had been so extensive that if outflows comparable with those in the Santa Barbara Channel existed, "they could hardly have escaped our notice."

HISTORY

One of the earliest known records of an offshore oil seep in California was in 1776 when Padre Pedro Font, while near Goleta, noted (as quoted by Heizer in 1943): "Much tar which the sea throws up is found on the shores, sticking to the stones and dry. Little balls of fresh tar are also found. Perhaps there are springs of it which flow out into the sea ...."

In 1792, Vancouver, Captain Cook's famous navigator, noted "a thick slimy substance with the strong smell of tar" in the Santa Barbara Channel. In 1839, Sir Edward Belcher, a British naval captain, noted "naphtha" on the surface of the water in the vicinity of Coal Oil Point. Another shipboard observer in 1886 wrote: "At two o'clock passed Goleta and saw petroleum spread over the sea, rising from submarine springs. As the ship throws aside the waters in her passage, a strong smell of coal oil is observed. I had often heard of this locality of the oil springs but I did not realize the extent of the surface covered or the significance from an economic standpoint."

In 1917, the National Research Council noted in their bulletin that an oil seep had been observed 10 miles off the coast of California between Redondo Beach and Santa Catalina Island. This seep is shown on the accompanying map (Plate I) as seep No. 4.

Probably one of the more active and better-known seeps south of the Santa Barbara Channel is the "Redondo" seep (Fig. 6) reported in "Geological Journeys in Southern California" (1939), which states that "near the center of Redondo Canyon is a submarine seep. On a clear day, petroleum and gas may be seen bubbling to the surface." These seeps remain active and occur along a seaward extension of the Palos Verdes Hills fault.

DOCUMENTATION

Finding and documenting offshore seeps is primarily

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dependent on visual observation. Oil and gas seeping to the surface forms oily patches or bubbles that are easily visible to aerial observers.

Where submarine observation is possible, the position of seeps may be accurately fixed, but restricted underwater visibility combined with the intermittent or varied flow of most seeps often makes visual contact with seep vents difficult. Some seeps apparently remain dormant for extended periods of time and then are reactivated by either a pressure build-up or, perhaps, earth movement. Because of the transient nature of many seeps, an accurate count is difficult to obtain. However, it appears that there are probably between 50 and 60 offshore seeps or seep areas between Point Conception, in Santa Barbara County, and Huntington Beach in Orange County. The Division of Oil and Gas has documented and cataloged more than 50 seeps within this area to date and is investigating reports of others.

The occurrence of submarine seeps north of Point Arguello has not been established. However, an oil seep associated with tar is known to occur in a sea cliff near Bolinas Point, and gas seeps have been reported at Duxbury Point (Douglas 1943), all in Marin County north of San Francisco. In Humboldt County, an active oil seep was observed onshore near False Cape (Ogle 1953) where Oil Creek enters the sea. Several additional oil seeps have recently been observed and recorded by the Division of Oil and Gas in coastal outcrops north of Cape Mendocino. Although a number of oil and gas seeps have been reported in this general area, there are no known offshore seeps. Oil, gas or tar seeps in areas near the sea may indicate that dormant or undetected submarine seepage exists offshore.

The accompanying map (Plate I) showing oil, gas and tar seeps, is based on information taken from published and unpublished sources, including scientific papers, articles, maps, and field observations.

GEOLOGIC BASINS

Geologic basins or structures that extend seaward and are known to produce oil, gas or tar onshore, are areas in which submarine seeps may occur offshore.

Although there are coastal areas north of the Santa Barbara basin that are potentially capable of submarine oil or gas seepage, only the Ventura-Santa Barbara and Los Angeles basins are definitely known to have seepage from the sea floor.

The Bear-Mattole and Eel River basins occupy more than half of the coastal portion of Humboldt County and include the towns of Eureka and Petrolia, a small community about 30 miles south of Eureka. A number of oil seeps have been located onshore within 10 miles of the coast in the vicinity of Eureka and some oil has been produced from wells in the Petrolia oil field. Although these basins appear to be possible sources for offshore oil seeps, none has ever been found.

The Santa Maria basin, in northern Santa Barbara County, lies within the Central Coastal area and includes several prolific oil fields. Among the productive areas is the Guadalupe field approximately 15 miles northwest of Santa Maria, which is producing oil from a structure known to extend offshore. However, there is no evidence of oil or gas seepage within the offshore portion of this basin.

The Ventura-Santa Barbara basin is a westerly trending depositional trough that includes an onshore portion, occupying most of Ventura County, and the submerged, or Santa Barbara Channel portion, which extends along the south coast of Santa Barbara County.

The onshore area includes not only a number of major oil fields but numerous oil and tar seeps. It was in this area that tar obtained from seeps was used by prehistoric Indians at least 7,000 years ago. Many seeps still flow oil within the area between Santa Paula and Ojai Valley, and tar and heavy oil can be seen in the cliffs along the south coast of Santa Barbara County. The natural tendency for this basin to literally leak oil onshore extends to the submerged or Channel portion where 38 seeps have been located and documented.

The Los Angeles basin includes among its many oil fields one of the largest fields in the world but relatively few onshore oil seeps. Nevertheless, the La Brea Tar Pits, one of the most famous tar seeps in the world, may be found in the northern portion of this basin and is known to have been in existence during Pleistocene time at least one million years ago. By extending the seaward margins of the basin to include the San Pedro mid-channel area, it is possible to account for, and document, eight oil or gas seeps with two additional seeps located near the northwesterly end of Santa Catalina Island.

Other depositional basins are known to exist along the California coast, and although some of these basins have produced oil or gas, present geologic conditions do not appear to be as favorable for the creation of submarine seeps as those basins previously described. However, earth movement or seismic disturbances could occur and result in faulting, fracturing or fissures in the sea floor that would allow oil, gas or tar to escape from geologic traps not presently known to exist.

SEEP AREAS

Point Conception

Point Conception is an area that includes oil, gas and tar seeps on a magnitude believed to approach that of the famous Coal Oil Point area near Santa Barbara.

The tar seeps and mounds were first examined and documented by scuba divers during the middle 1950's, and first photographed during the winter of 1961-1962 by J. W. Vernon and R. A. Slater during their underwater study of seepage in the area. Submarine seepage here includes a number of separate vents, one of which (Fig. 1) was photographed in 90 feet of water 1½ miles offshore and several miles east of Point Conception. Vernon and Slater (1963) state that "Tar mounds have been observed on the Southern California sea floor at only three localities: The Point Conception area, Coal Oil Point near Goleta and off Carpinteria. Tar is most abundant near Point Conception where a sheet of tar covers an area at least one-fourth square mile and forms a 10 to 12 foot scarp at seaward edge."

Tar mounds are the result of tar accumulating around a seep or vent. Why some tar floats to the surface while the remainder forms mounds is explained by Vernon and Slater -- "Tar is extruded slowly from the vent forming a tapered whip-like strand which floats, but remains attached to the vent until it is at least several feet long. A strand 12 feet long was observed which tapered from six inches at the base to pencil-thickness at the tip. ... Factors which contribute to a gradual density increase are loss of gas and light petroleum fractions, contraction due to cooling and accumulation of sediment and organisms. If seepage is slow enough the attached "whips" become more dense than sea water and sink, becoming part of the mound." The source of these seeps appears to be from fractures in shallow dipping Monterey Shale which crops out on the sea floor.

Oil and gas seeps occur about two miles from shore just east of the Phillips Petroleum Company's platform "Harry". Although these seeps are not known to have been studied on the sea floor, an extensive oil slick in this vicinity has been observed and photographed by the author while flying over the area. The source of oil here is also thought to be from the Monterey Formation, the same geologic formation that is believed to form submarine seeps off Coal Oil Point.

Coal Oil Point

Coal Oil Point is now possibly the world's most publicized submarine seep. Although it is usually referred to as "*the* Coal Oil Point seep" it is actually an area of many small individual seeps that appear to be grouped into three general areas of seep activity. Although no official designation has been made, some observers have described the areas as the "Coal Oil Point" seep, the "La Goleta" seep, and the "Isla Vista" seep (Fig. 2). These separate areas are not visible, as such, unless wind and current conditions are favorable. When conditions are not favorable there is a tendency for the individual slicks to blend into one semi-continuous mass. Figure 3 shows the "Coal Oil Point" seep under favorable sea conditions with the wind from the east, and the characteristic streak pattern so noticeable from the air.

Although the submarine seeps off Coal Oil Point have been casually observed by divers in the past, they have more recently been studied in some detail by Allen and Schlueter (1969) who made numerous dives while attempting to determine a rate of seep flow for this area. Their sea floor observations were confined to the "Coal Oil Point" seep area and the "Isla Vista" seep area (Fig. 2).

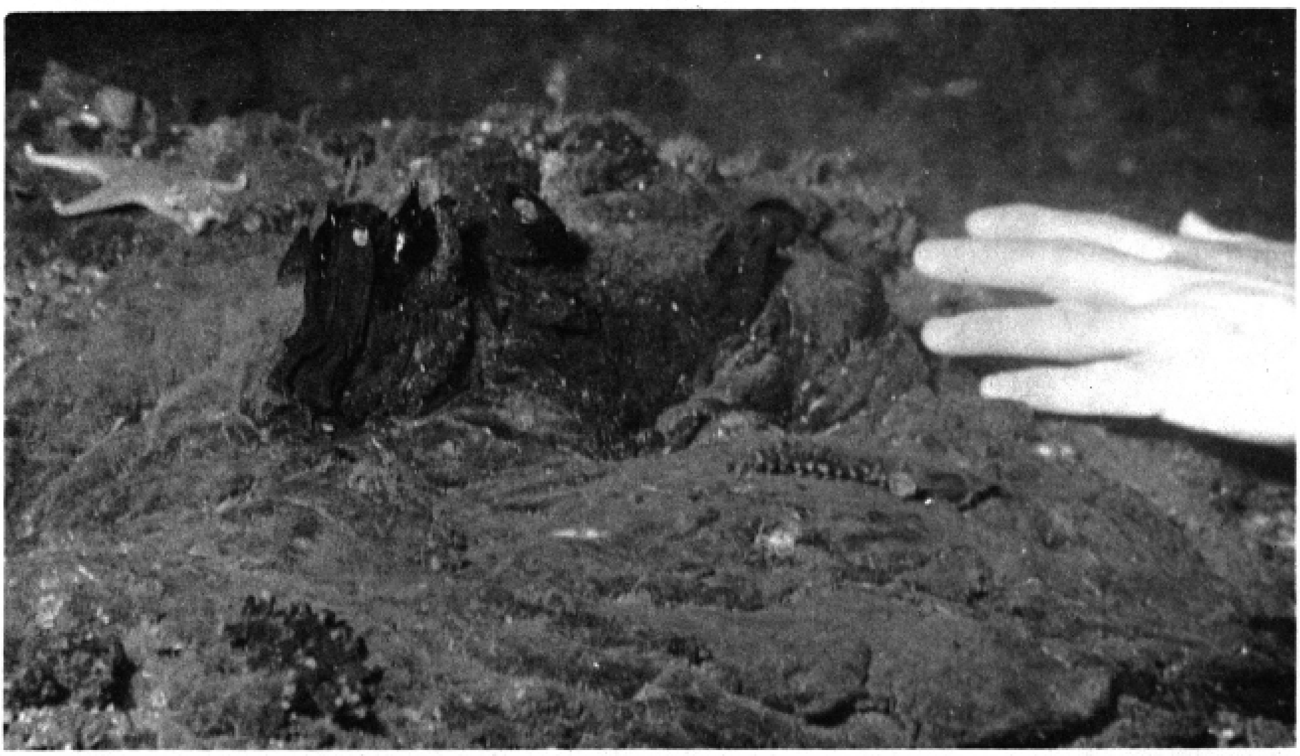

Figure 1.– Submarine tar seep in 90' of water, 1½ miles offshore and several miles east of Point Conception. The darker tar in the center of the mound shows where tar exudes from the vent forming a globule and floats to the surface. Photo by James W. Vernon and Richard A. Slater, 1962.

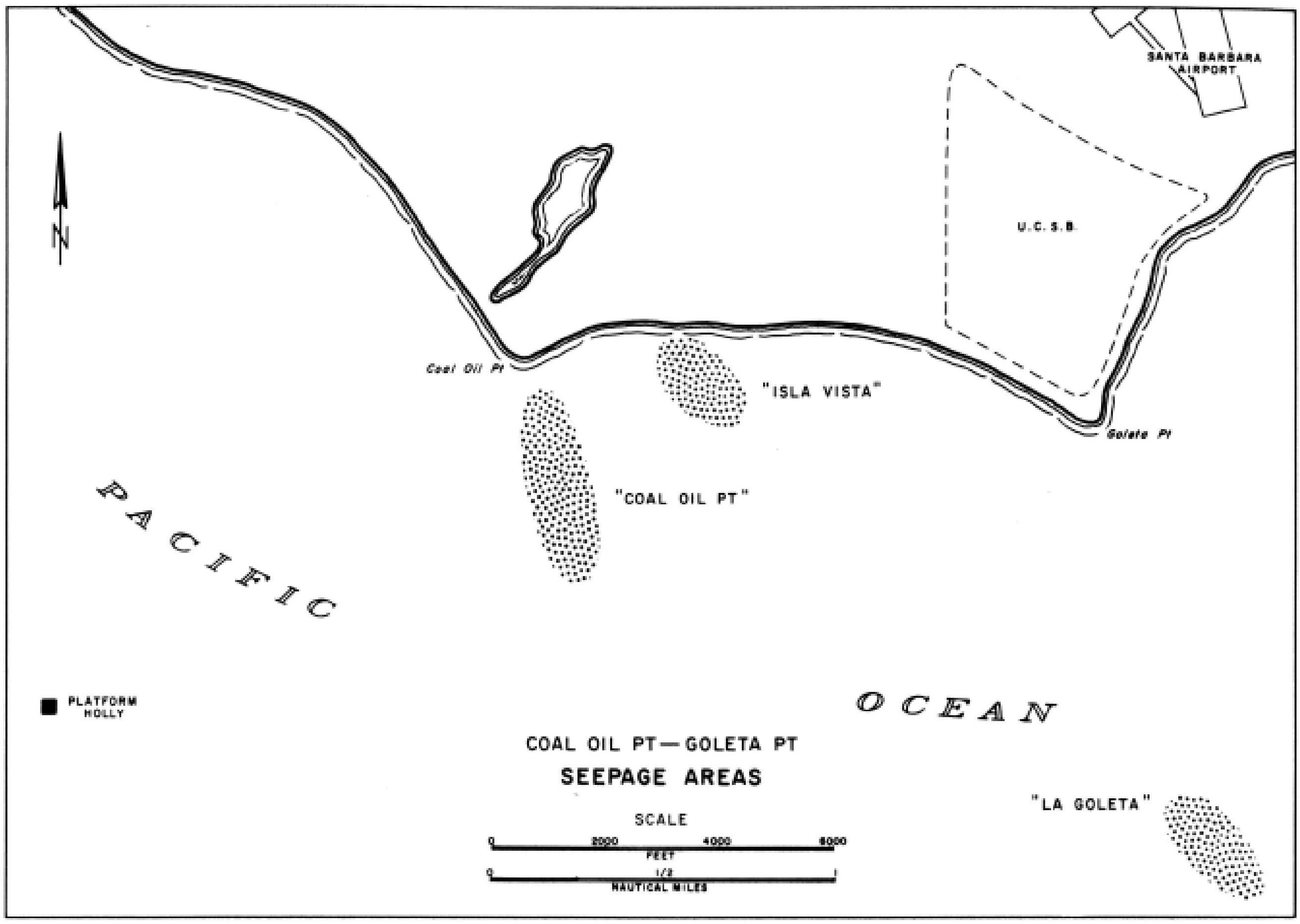

Figure 2

Figure 3. – Aerial view of submarine oil seep off Coal Oil Point, 1970 (Looking North).

The "Coal Oil Point" seep area may be further divided into three separate areas of seep vents within the general area. One, close inshore at a depth of 45 feet, forms a line about 150 feet in length trending 10 degrees west of north. Figure 4 shows a globule of oil emerging from the sea floor off Coal Oil Point. It is of interest to note that the sea urchin in the right foreground of the photograph is apparently unaffected by the numerous small oil seeps in the immediate vicinity.

The action of the seep is described by Allen and Schlueter as follows: "The oil is extruded from the individual leakage sources in much the same manner as tooth paste is squeezed from a tube. Since the oil is less dense than the sea water, it moves upward from the bottom and forms a small globule or 'head' with an attached stringer that is connected to the source. Several of these globules were collected as they were extruded from the bottom and were found to contain 2 to 3 cubic centimeters of oil per globule."

Two other seepage areas within the general "Coal Oil Point" seep area extend southward on a continuation of the first seep line previously described. The line of seepage reaches an overall length of approximately one-fourth of a mile along a trend which is apparent in the aerial photo (Fig. 3) showing the characteristic pattern created by oil and gas rising to the surface along this line.

The seeps in the "Coal Oil Point" area originate from a sea floor that is both rocky and sandy, and varies in depth from 45 feet near shore to approximately 100 feet near the outer or seaward edge of the seepage.

There has been no submarine investigation made of the "La Goleta Seep" area, but aerial observation indicates a relatively large slick forms from these seeps suggesting that seep activity may be comparable to that at Coal Oil Point.

On the basis of Allen and Schlueter's investigation of the "Coal Oil Point" area, seepage has been estimated to occur at a rate of 50 to 70 barrels of oil per day. This estimate indicates that a substantial amount of oil was seeping from the sea floor at the time of the investigation and although some observers have stated that the rate of seepage appears to have increased during the past two years, others maintain that the variations are seasonal with flow volumes increasing only during the summer months. Unless periodic estimates of the flow volume are made, seasonal variations in the flow rate cannot be substantiated.

There is no current explanation for this phenomenon, if it is indeed true. Daily or even monthly variations in the seepage rate might be logically attributed to a change in water depth caused by the normal tide cycles. However, it does not seem that semi-annual variations in seep rates can be the result of tidal fluctuations.

Platform "A" Seep

Oil and gas seepage in the vicinity of Union Oil Company's platform "A", approximately five miles offshore from Santa Barbara, is almost entirely the result of a blowout which occurred early in 1969. However, at least one natural seep was observed in the area and documented by Union Oil Company of California prior to installation of the platform. On February 29, 1968, Mr. F. J. Simmons, District Drilling Superintendent informed the U. S. Geological Survey that "a fairly large oil slick with some gas bubbles" had been sighted on their OCS lease P-0241, and "From all indications and records available to us, this is apparently a natural seep" (McCulloh, 1969).

The source of seepage is a shallow oil sand in the Repetto Formation which is reported to be overlain here by a very thin blanket of poorly consolidated sediments that form the sea floor. Seepage apparently occurs along the axis of an anticline which forms part of the Rincon trend, a series of anticlinal structures curving westward into the Channel from onshore Rincon field.

On January 28, 1969, a well being drilled from platform "A" penetrated a high pressure zone below 3,400 feet. Gas from this zone started flowing up the well bore to the surface. The well was closed in and remained temporarily under control, but pressure continued to increase within the well until gas-charged drilling fluid finally broke through the uncased portion of the hole into the shallow oil sand lying just below the sea floor. The gas soon permeated the sand apparently forming fissures through which the now gas-saturated oil literally erupted from the sea floor forcefully expelling oil and gas into the sea.

The initial leak caused by the blowout occurred near the northeast leg of the platform (Fig. 5), but about two hours later this was followed by a heavier flow some 800

Figure 4. – Oil globule shown at the left rising from seep in the sea floor off Coal Oil Point. Note sea urchins (Strongylocentrotus franciscanus) in foreground and calibrated jug at extreme right of photo.

feet east of the platform. Additional seepage was discovered between this later seep and the platform within 24 hours.

Estimates of flow rates have varied to a considerable extent. Union Oil Company personnel present at the site during the blowout, stated that oil was leaking at the rate of 500 barrels per day during the first 10 days. However, Allen (1969) basing his estimate on data from aerial photographs and color characteristics of the slick, estimated the volume as 5,000 barrels per day.

By October 1969, wells were producing from the shallow oil sand, resulting in a lowered reservoir pressure; in addition gas and oil from the deep high pressure zone in the blowout well were prevented from reaching the shallow sand, thereby eliminating the source of repressurization. As a consequence, seepage rates declined to an estimated 12 barrels per day.

As of January 1972, there appeared to be two seep areas west of platform "A" and probably 5 or 6 east of the platform. An accurate evaluation of seep activity based on surface observation is complicated by the use of submarine tents which prevent seepage from reaching the surface. Also, normal wind and current conditions tend to consolidate oil slicks making identification of individual seeps difficult.

Redondo Beach

The most active seeps found south of Coal Oil Point occur in the vicinity of Redondo Beach. Numbers 8, 9 and 10 shown on Plate I indicate the approximate location of this seepage. Figure 6 shows each of the individual seeps observed off the coast of the south Santa Monica Bay area in greater detail.

Recent observations indicate that six separate seeps may be found along the submarine trace of the northwest-trending Palos Verdes fault (Figure 6). The seep nearest land is located about two miles off Redondo Beach, and originates near the head of the Redondo submarine canyon in a water depth of approximately 800 feet. Five additional seeps occur along a twelve-mile prolongation of the fault, including the "Manhattan" seeps located 4 to 5 miles off this city's beach, and the "Venice" or most seaward seep nearly 8 miles off Venice Beach.

Seep activity normally varies to a certain extent, with some seeps remaining dormant for extended periods of time. However, observers have recently noted an apparent increase in the activity of these seeps off the South Bay coastal area. Estimates of flow rates are based on physical size of the slicks, and considering this somewhat inaccurate method of evaluation, each seep is currently estimated to produce 12 to 15 barrels of oil per day, and an undetermined amount of gas. The constant stream of gas bubbles rising to the surface of the sea is reported to be a great attraction for fish. Two of these seep areas are sufficiently well known to be shown on U. S. Coast and Geodetic Survey charts covering the Santa Monica Bay.

The oil slicks produced by this seepage are the cause of much controversy. Depending on wind and tide, tar in varying amounts is deposited on the beach; this popular

Figure 5. – Oil and gas bubbling to the surface near the leg of Union Oil Company Platform "A" in Santa Barbara Channel during blowout on January 28, 1969.

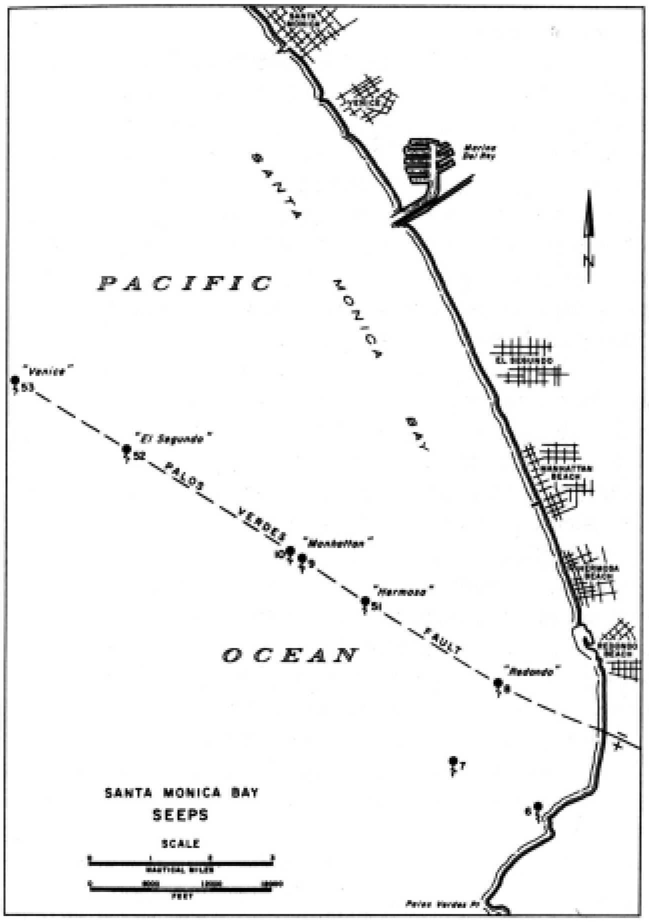

Figure 6

recreation area is visited by thousands of people each year, and many find the tar a messy nuisance. Oil refinery and marine loading-terminal operations at El Segundo are frequently blamed for much of the beach pollution that apparently originates from these submarine seeps.

A recent submarine study of these seeps was made by scientists of the Marconsult Corporation to learn more about the oil and gas emission rates, the direction of surface drift, and the approximate amount of oil emitted by these seeps that finds its way to the beach. A series of samples were collected from the beach area between El Segundo and Redondo Beach. It was found that 86 percent of the samples contained oil that originated from natural seeps offshore. Los Angeles County officials are currently considering the feasibility of placing submarine tents over these sea-floor seeps. This is perhaps the only means of curbing beach pollution from these natural sources.

Malibu

The relationship between seeps and earthquakes appears to have been demonstrated to some degree during the major earthquake which occurred in Southern California early in 1971. Although the Malibu seepage was of short duration, it did provide an opportunity for geologists and engineers to observe and record this natural phenomenon in some detail.

On February 9, 1971, bubbles of gas were discovered rising to the surface of the ocean approximately 200 yards off the Malibu Pier. The Los Angeles County Life Guard Patrol noted that the bubbles had appeared shortly after the earthquake which occurred on that date. The following day the seep was found by divers to consist of a series of small individual seeps occurring along a line extending southwesterly at least 800 feet from a point 200 yards slightly southwest of the end of the Malibu Pier (Fig. 7).

On the day of the earthquake other seeps were noted along a line originating at the easterly end of the previously noted seep line and extending northwesterly some 300 feet. However, by February 10th, bubble activity along this line had declined to the point that it was no longer visible.

Scuba divers reported that the seeps appeared to emanate from the sandy bottom of the sea floor as individual columns of bubbles occurring along the previously described lines. Plastic bags placed over individual seep vents required about 20 minutes to recover approximately three-fourths of a cubic foot of gas.

In the opinion of those present on February 9th, the seep activity had declined approximately 75 percent by February 10th and by February 15th was no longer visible. Under the circumstances it appears that the earthquake centered in San Fernando Valley also caused earth movement in the Malibu area which fractured the thinly covered Monterey Shale offshore. As a result, a limited amount of methane gas was released through the overlying sandy bottom of Keller Cove creating a temporary submarine gas seep.

SEEP FLOW-RATE AND VOLUME

The volume of oil produced by an individual seep during a given time is difficult to determine under ideal conditions, but since most seeps apparently occur as seep areas which include a multitude of small individual seeps, the calculation of total volume released is extremely difficult. In addition, it is sometimes necessary that the volume of a seep, leak or oil spill be determined quickly and with reasonable accuracy.

During the latter part of 1969, an attempt was made by Allen and Schlueter to find a reliable and inexpensive procedure for estimating the quantity of oil flowing to the surface near platform "A". In general, the object was to investigate an actual seep area, in this case Coal Oil Point, place calibrated collecting bottles over representative seep vents within a measured area, and determine the volume of oil emitted from that area. After determining an approximate rate of flow from the source, a study of the slick formed on the surface was made. A considerable amount of field and laboratory work was needed to finally determine a relationship between the physical appearance of an oil slick and the

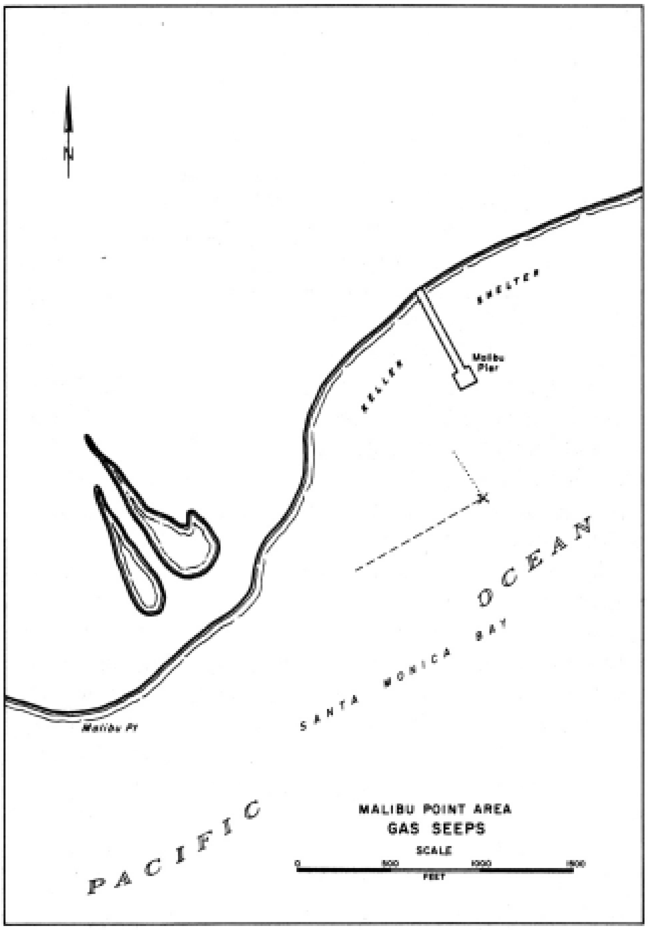

Figure 7

volume of oil involved.

In determining oil slick thickness Blockker (1964) found that as much as 20 percent of a typical crude oil slick can be evaporated in the presence of strong winds and turbulent waters. After taking this and other factors into consideration the volume of oil per square foot in an oil slick was calculated and the corresponding thickness established. It was also noted that a relationship existed between the oil film appearance on the water and the film's thickness. This relationship is shown on the accompanying graph (Fig. 8).

Although the determination of oil slick thickness by appearance is dependent on several variable conditions, including wind, current, light, angle of observation and the observer's own evaluation of these physical conditions, the method developed is relatively simple and should prove useful.

"FINGERPRINTING" OIL

For more than 50 years scientists have tried to find some identifying characteristic in crude oil that would link an oil slick to its source. Early attempts at chemical identification were largely dependent upon the amount of sulphur present, but more recent techniques use a combination of trace metals and other chemical properties that provide a more dependable result under varying conditions.

The identification or "fingerprinting" process will usually involve a chemical analysis to determine the presence and amounts of the elements vanadium, nickel, sulphur and nitrogen. In addition, some form of mass spectra analysis is made, usually with an infrared spectra photometer, to measure the paraffinic character of the oil, as well as other compounds that may be present. The result of this combination of analyses is a set of chemical characteristics peculiar to a specific sample of oil derived from a single source or source area.

Unfortunately for "fingerprinting", oil exposed to weathering undergoes changes in composition. Whisman and Cotton (1971) found the effects of weathering so important that they concluded: "Using the premise that several properties would be necessary for identification, we selected properties that would not be changed appreciably during short-term weathering .... Oil following a spill undergoes changes in composition because of the action of water, wind, sunlight, and after a time, micro-organisms". They also found, after artificially weathering a number of samples, that, "In all cases the loss of light ends during weathering raised the concentration of the determined component."

It now appears that of all the trace elements that may be present in a sample of crude oil, nickel and vanadium are the least affected by weathering. As a result the ratio of nickel to vanadium will be consistent for a specific sample and becomes an important part of the "fingerprint".

Although oil from different sources may exhibit characteristics that identify the source, the oil must be unweathered. The chemical composition of oil that has been floating on the surface of the ocean for a number

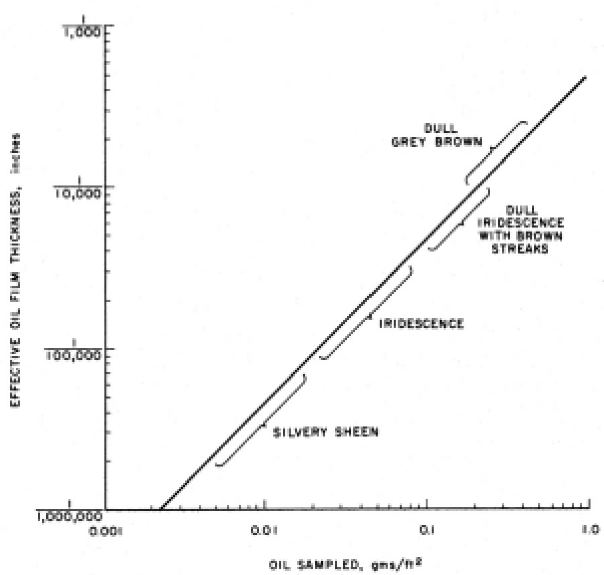

Figure 8. – Oil film appearance and effective thickness as a function of the mass of oil collected (p = 0.9 gm/cc) taken from technical memorandum 1230, General Research Corporation.

TABLE 1

CATALOG OF OIL AND GAS SEEPS

	LOCATION	Lat. & Long.	References	Remarks
1.	Coronado	32° 28'20"N 117° 21'30"W	Oil Age, 1923	Questionable - May be a spill
2.	Catalina, west end	33° 28'20"N 118° 36'50"W	Western Oil & Gas Assoc., 1931	½-acre oil slick sighted from steamer, 1923 Frequently sighted by fishermen; now inactive
3.	Catalina, west end	33° 29'10"N 118° 36'30"W	See 2	See 2
4.	San Pedro Channel	33° 35'40"N 118° 20'30"W	U.S. Bureau of Mines, 1923 Calif. Academy of Science, 1917	Oil droplets & slabs of tar as large as 8"x5"x1"
5.	Huntington Beach	33° 40'10"N 118° 01'50"W	Signal Oil and Gas Co.	Gas bubbles from outcrop, probably of marsh gas sands
6.	Palos Verdes	33° 48'10"N 118° 24'40"W		
7.	Redondo Beach	33° 49'00"N 118° 26'10"W	U.S. Bureau of Mines, 1923	Oil and gas, about 3.5% sulfur Intermittent flow in 1927; no estimate made Oil slick about 50 acres in 1928
8.	Redondo Beach	33° 50'10"N 118° 25'30"W	University of Southern California	Oil and gas On line of Palos Verdes fault
9.	Manhattan Beach	33° 52'10"N 118° 27'40"W	Seismological Soc. America, 1920 Standard Oil Co. of California and W. T. Knowlton, 1928	Oil and gas, about 4% sulfur 9 & 10 together estimated to be discharging about 10 barrels of oil per day in 1928 200- to 400- acre oil slick On line of Palos Verdes fault
10.	Manhattan Beach	33° 52'20"N 118° 29'20"W	See 9	See 9
11.	San Miguel Island	34° 04'30"N 120° 25'20"W	Western Oil & Gas Assoc., 1931 Oil and Gas Journal, 1937	First noted by U.S. Coast & Geodetic Survey in 1875 Oil and gas
12.	Santa Cruz Island	34° 03'20"N 119° 54'10"W	Papers written about the island in French in 1893 and translated by Dr. Redwine, Union Oil Co.	Mostly tar
13.	Santa Cruz Island	34° 00'40"N 119° 53'40"W	Emery, 1960	Mostly tar
14.	Santa Barbara Channel	34° 02'20"N 119° 16'10"W	Emery, 1960	Discovered by continuous presence of oil, gas bubbles, and tar on the water
15.	Santa Barbara Channel	34° 08'00"N 119° 41'24"W	Standard Oil Co. of California	See 14
16.	Platform A	34° 20'20"N 119° 36'30"W	Lewis & Lewis (surveyors for Union Oil Co.), 1968	Discovered before platform was installed about 800 feet from platform Oil and gas from saturated shale outcrop
17.	Platform Houchin	34° 20'00"N 119° 33'40"W	U.S. Geological Survey	
18.	Platform Heidi	34° 21'00"N 119° 30'20"W	Mattei, 1929, in Santa Barbara newspaper	On crest of anticline
19.	Rincon Trend	34° 21'30"N 119° 29'40"W	L. S. Fox, 1930	Gas bubbles from crest of anticline
20.	Rincon Point	34° 22'50"N 119° 29'30"W	Whitney, 1865	From fractured Monterey Formation
21.	Carpinteria	34° 23'30"N 119° 31'20"W	Father Crespi, 1770	Gas bubbles
22.	Carpinteria	34° 23'40"N 119° 32'10"W	Father Crespi, 1770	Similar to seeps on shore
23.	Montecito	34° 25'00"N 119° 38'00"W	Calif. Div. Mines Bull. 118	Probably on a fault
24.	Montecito	34° 25'00"N 119° 38'30"W	Calif. Div. Mines Bull. 118	See 23
25.	La Mesa	34° 21'40"N 119° 44'30"W	Standard Oil Co. of Calif.	
26.	Hope Ranch	34° 22'00"N 119° 46'20"W	Standard Oil Co. of Calif.	
27.	Hope Ranch	34° 24'20"N 119° 45'50"W	Standard Oil Co. of Calif.	
28.	Coal Oil Point	34° 23'40"N 119° 51'40"W	Father Pedro Font, 1776 Sixth Annual Report, State of Calif. Mineralogist, 1886 Allen & Schleuter, 1969	Best known seep area Oil, gas and tar. Oil is 12.4 gravity Typically, oil is released as globules from sand patches, some of which are in line and some of which are independent Estimated discharge for area: Max. 160 bbls. oil per day Min. 11 bbls. oil per day Avg. 50-70 bbls. oil per day More than induced seeps at Platform A
29.	Coal Oil Point	34° 24'00"N 119° 52'40"W	See 28	See 28
30.	Coal Oil Point	34° 24'30"N 119° 52'00"W	See 28 J. Eaton, geologist, 1931	See 28
31.	Platform Holly	34° 24'30"N 119° 54'40"W	Sixth Annual Report, State of Calif. Mineralogist, 1886	Probably similar to Coal Oil Point

TABLE 1 – Continued

CATALOG OF OIL AND GAS SEEPS

	LOCATION	Lat. & Long.	References	Remarks
32.	Naples	34° 25'30"N 119° 57'30"W	Holder, 1910	Tar in shale
33.	Capitan Beach	34° 27'20"N 120° 00'30"W	Holder, 1910 Standard Oil Co. of Calif.	At intersection of faults
34.	Refugio	34° 26'00"N 120° 03'30"W	Holder, 1910	Probably from Monterey Formation Oil slicks noted on water
35.	Molino	34° 28'00"N 120° 09'20"W	Holder, 1910 Standard Oil Co. of Calif.	See 34
36.	Gaviota	34° 27'30"N 120° 13'30"W	Holder, 1910 Standard Oil Co. of Calif.	See 34
37.	Platform Helen	34° 26'50"N 120° 17'00"W	Standard Oil Co. of Calif.	Faulted area
38.	Cuarta	34° 27'30"N 120° 17'30"W	Standard Oil Co. of Calif. Emery, 1960	Faulted area
39.	San Augustine	34° 26'40"N 120° 20'30"W	Union Oil Co. of Calif. Emery, 1960	
40.	Platform Herman	34° 26'00"N 120° 22'20"W	Union Oil Co. of Calif. Emery, 1960	
41.	Cojo	34° 27'20"N 120° 24'30"W	Standard Oil Co. of Calif. Emery, 1960	Fractured shale on faulted anticline
42.	Point Conception	34° 26'20"N 120° 26'50"W	Standard Oil Co. of Calif. Emery, 1960	Fractured shale on faulted anticline
43.	Point Conception	34° 26'40"N 120° 28'30"W	Mattei, 1929 Standard Oil Co. of Calif.	Oil, gas and sulfur water seeps onshore Globs of tar more than 1 ft. in diameter Type of tar indicates seepage from Monterey Formation
44.	Point Conception	34° 28'00"N 120° 29'00"W	See 43	See 43
45.	Santa Barbara Channel	34° 06'40"N 120° 23'04"W	J. Stearns, 1969	Oil slick sighted from air Location approximate
46.	Platform Holly	34° 23'30"N 119° 55'00"W	Atlantic Richfield Co.	
47.	Platform Holly	34° 23'30"N 119° 56'10"	Atlantic Richfield Co.	First observed in 1969 Discharge less than 1 bbl. oil per day at present
48.	Platform A	34° 20'20"N 119° 36'30"W	U.S. Geol. Survey Prof. Paper 679	
49.	Point Dume	33° 59'10"N 118° 46'20"W	Standard Oil Co. of Calif.	At 50 fm. contour on line between Pt. Dume & Pt. Vicente
50.	White's Point	33° 42'50"N 118° 19'10"W	Emery, 1960 Standard Oil Co. of Calif.	Analyzed by Atlantic Richfield Co.
51.	Hermosa Beach	33°51'27"N 118°28'10"W	Standard Oil Co. of Calif.	Oil seep
52.	El Segundo	33° 53'35"N 118° 32'55"W	Standard Oil Co. of Calif.	Oil seep
53.	Venice	33°55'05"N 118°35'05"W	Standard Oil Co. of Calif.	Oil seep
54.	Platform Heidi	34°20'30"N 119°30'45"W	Calif. Div. of Oil and Gas	Gas bubbles

of days cannot be traced chemically without taking into consideration the degree of chemical alteration that may have taken place. Therefore, it is necessary that a sample of oil from the suspected source be artificially weathered prior to analysis so that it will more closely approximate the altered composition of the floating oil slick.

Although the benefits of oil identification are numerous it would be especially helpful to be able to determine if an oil slick originated from a vessel or from a natural seep off our coast. Oil found on the beach may simply be the normal result of a natural offshore seep.

CONCLUSIONS

Offshore oil seeps have been in existence off the Southern California coast for thousands of years, but until recently relatively little was known of their whereabouts or the mechanics of seepage. Although all of the known submarine seeps are south of Point Conception, several potential areas north of this point, particularly Point Arena and the Humboldt coast, would be prime areas of investigation for possible seepage since there are oil seeps onshore near these areas.

Studies to this date have shown no lasting detrimental effect on the marine environment in the Santa Barbara Channel. Further studies of individual seeps and seep areas are being conducted in this area by the Allan Hancock Foundation (Straughan, 1971) to learn more about the effect that oil and gas have on the animal and plant life in the immediate vicinity, and whether unusual adaptations have resulted from long exposure to natural hydrocarbons.

Oil from many seep areas has been analyzed and the identifying chemical characteristic or "fingerprint" established and cataloged for reference. At this time the rate at which oil flows from the sea floor cannot be gauged except on an order of magnitude basis, but as most seeps vary in rate throughout the year, perhaps this is sufficient.

Additional studies of a very expensive nature have been proposed for combatting the problems arising from an oil accumulation on the ocean or on the beaches. Items such as the source, and therefore, the type of oil, the amount of oil, the direction and rate of the ocean current, and the direction of the wind have been nominated for studies requiring large sums of money. The number of variables for any one problem at a given time make the benefit of such an expenditure questionable.

This report covering oil seeps in California waters delineates their location and volume. Samples have been taken of the larger ones. The added information to be gained from additional in-depth studies would add little knowledge, as it is believed that all significant, active, near-shore seeps have been located.

SELECTED BIBLIOGRAPHY

1. Allen, A. A., and Schlueter, R. S., 1969, Estimates of Surface Pollution Resulting from Submarine Oil Seeps at Platform "A" and Coal Oil Point: General Research Corp. Memo 1230.
2. Bickmore, D. K., 1967, Offshore-onshore Petroleum Study, Santa Barbara Channel. Phase I, Effects of Federal Leasing, Outer Continental Shelf (Prelim. Rept.): Oil Well Inspection Dept., Santa Barbara County, Calif., Vol. 1.
3. Blockker, P. C., 1964, Spreading and Evaporation of Petroleum Products on Water, published in proceedings on the Fourth International Harbor Conference, June 1964, Antwerp, Belgium.
4. California Division of Oil and Gas, 1961, California Oil and Gas Field Maps and Data Sheets, Part 2, Los Angeles-Ventura Basins and Central Coast Ranges: California Division of Oil and Gas, p. 495-913.
5. Douglas, J. M., 1943, Duxbury Point region, *in* Jenkins, O. P., (ed), Geologic Formations and Economic Development of the Oil and Gas Fields of California: California Div. of Mines Bull. 118, p. 621.
6. Fewkes, J. W., 1889, Across the Santa Barbara Channel: Am. Naturalist, Vol. 23, p. 387-394.
7. Hamilton, R. M., Yerkes, R. F., Brown, R. D., Burford, R. O., and De Noyer, J. M., 1969, Seismicity and Associated Effects Santa Barbara Region: U. S. Geol. Survey Prof. Paper 679-D, p. 47-68.
8. Heizer, R. F., 1943, Aboriginal Use of Bitumin by the California Indians, *in* Jenkins, O. P., (ed), Geologic Formations and Economic Development of the Oil and Gas Fields of California: California Div. of Mines Bull. 118, p. 74.
9. Imray, J. F., 1868, Sailing Directions for West Coast of North America, Part 1: London, James Imray and Son.
10. Journal of the American Shore and Beach Preservation Association, 1936, p. 129.
11. Kolpack, R. L., 1971, Biological and Oceanographical Survey of the Santa Barbara Channel Oil Spill, Volume II Physical, Chemical and Geological Studies: Allan Hancock Foundation, University of Southern California.
12. Livingstone, A., 1939, Geological Journeys in Southern California, Wm. C. Brown Co., 2nd Edition, p. 6.
13. McCulloh, T. H., 1969, Geologic Characteristics of the Dos Cuadras Offshore Oil Field: U. S. Geol. Survey Prof. Paper 679-C, p. 29-46.
14. National Research Council, 1917, National Academy of Science, Vol. 16, part 2, p. 41-44.
15. Ogle, B. A., 1953, Geology of the Eel River Valley Area, Humboldt County, California: California Div. of Mines and Geology Bull. 164, p. 128.
16. Oil Age, 1923, v. 20, no. 3.
17. Ramsdale, S. J., and Williamson, R. E., 1968, Identification of Petroleum Sources of Beach Pollution by Gas-Liquid Chromatography: Jour. of the Petroleum Institute (London), Vol. 54.
18. The Resources Agency of California, 1970, The Offshore Petroleum Resource, The Resources Agency of California.
19. Scripps Institution of Oceanography, 1913, *in* the 14th Annual Report of the State Mineralogist (1913-1914), 1915, p. 708-709.
20. Vedder, J. G., Wagner, H. C., and Schoellhamer, J. E., 1969, Geologic Framework of the Santa Barbara Channel Region: U. S. Geol. Survey Prof. Paper 679-A, p. 1-11.
21. Vernon, J. W., and Slater, R. A., 1963, Submarine Tar Mounds, Santa Barbara County, California: Am. Assoc. Petroleum Geologists Bull., Vol. 47, No. 8, p. 1624-1627.
22. Wagner, H. R., 1929, Spanish Voyages to the Northwest Coast of America in the Sixteenth Century. San Francisco, Calif. Hist. Soc., Spec. Publ. 4.
23. Weaver, Donald W., 1969, Geology of the Northern Channel Islands: Pacific Sections of Amer. Assoc. of Petroleum Geologists, and Society of Economic Paleontologists and Mineralogists.
24. Whisman, M. L., and Cotton, F. O., 1971, Bumines Data Promise Help in Identifying Petroleum-Spill Sources; The Oil and Gas Journal, Vol. 69, No. 52.
25. Yerkes, R. F., Wagner, R. W., and Yenne, K. A., 1969, Petroleum Development in the Santa Barbara Channel Region: U. S. Geol. Survey Prof. Paper 679-B, p. 13-27.

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